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# STABILIZING SOIL WITH PORTLAND CEMENT

## *Experiments by South Carolina Highway Department*

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INVESTIGATIONS of soil-cement mixtures with the idea of using these materials in the construction of low-cost roads were first started in the laboratory of the South Carolina Highway Department in 1932, at the suggestion of the late Dr. C. H. Moorefield, who was, at that time state highway engineer. After laboratory studies showed that the soil-cement mixtures would harden and have appreciable resistance to weathering, a field experiment 528 ft. long was constructed in a good sand-clay soil during December, 1933. Cement was applied to the surface of this section at the rate of one bag per linear foot of 20-ft. roadway as observation of laboratory specimens indicated that this quantity was necessary. The cement and dry soil were mixed

*Fig. 2.—Scarifying to Pulverize*

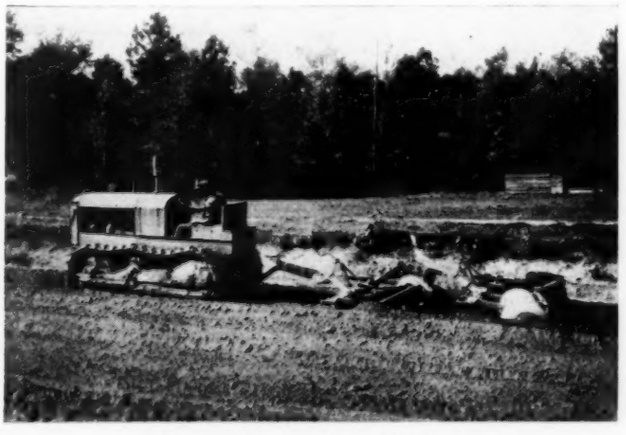

*Fig. 3.—Pulverizing with Discs*

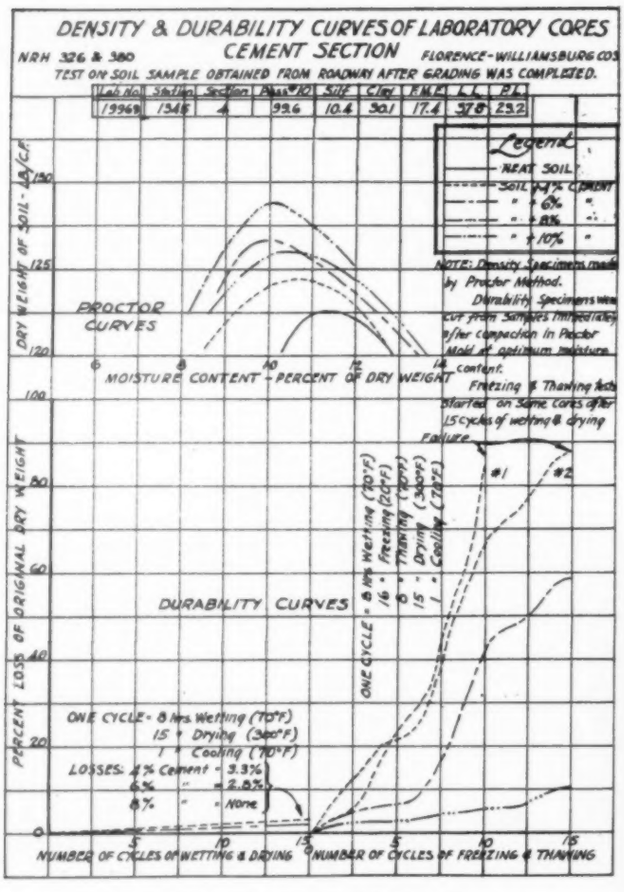


*Fig. 1.—Density and Durability Curves*

in place, then water was added until the mixture was damp and it was compacted by trucks and a roller. The surface was shaped with a road machine and the experiment was opened to traffic two days later. This section was surfaced with a thin bituminous mat after it had been under traffic for about one year. At this time some ruts and pot-holes had developed, but there was no indication of a general break-down. It was observed that the surface was not slick during wet weather.

Four other preliminary field experiments each approximately 1,000 ft. long were constructed in July, 1934. These experiments were located in different parts of the state so as to include several different types of soils. They were covered with a thin bituminous wearing course and are apparently in a good condition at the present time. The Portland Cement Association furnished cement for these experiments.

## Johnsonville Experiment

In the fall of 1935, the Portland Cement Association cooperated with the highway department in the construction of a soil-cement experiment approximately 1½ miles long. This experiment was a part of a 3.9 mile experiment to study three methods of stabilizing soil. Tar was used on 1 mile and cut-back asphalt on 1.4 miles.

The soils in the entire project are similar and consist of a natural mixture of fine sand and clay. The clay content varies considerably and wide variations were found within a few hundred feet. The clay content varies from the minimum of 9.8 per cent to a maximum of 30.5 per cent with an average of 20.0 per cent, and on the average only 14.0 per cent is retained on the No. 60 sieve. The soil in the subgrade was used in every instance and no attempt was made to fit any of the above stabilizing materials to any particular location.

*Preliminary Laboratory Studies.*—A plan for a series of preliminary laboratory investigations and an outline for the field work were submitted by the Portland Cement Association and adopted by the highway department. This preliminary laboratory work was predicated on the principles of soil compaction established by R. R. Proctor of the Los Angeles Water Board and on the durability or resistance of hardened soil-cement mixtures to repeated wetting and drying and freezing and thawing.

Tests were conducted to determine the moisture-density relation or optimum moisture content of the raw soil and the soil-cement mixtures. This information was used

*Fig. 4.—Spreading Cement*

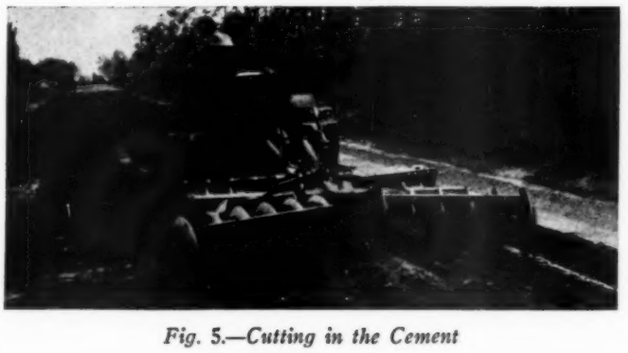

*Fig. 5.—Cutting in the Cement*

*Fig. 6.—Mixing Operation*

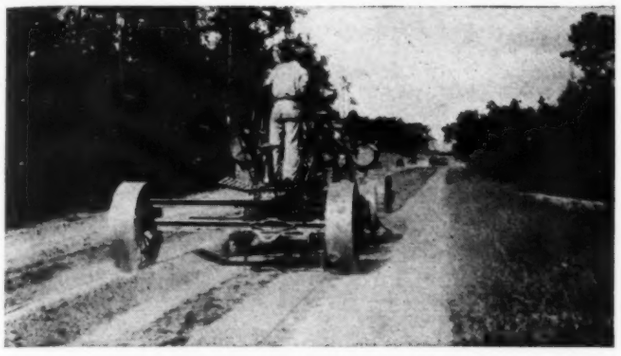

*Fig. 7.—Mixing Cement and Soil*

*Fig. 8.—Applying Water*

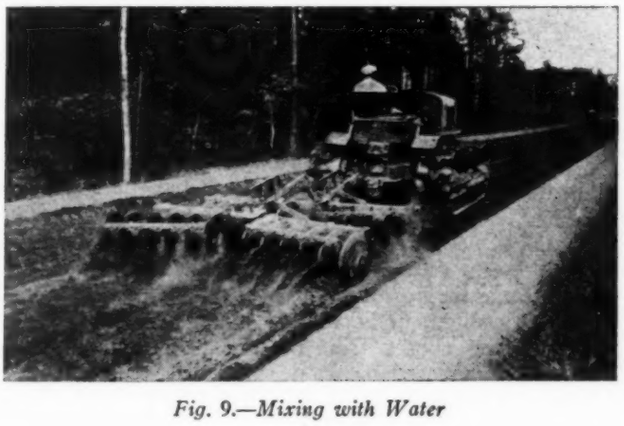

*Fig. 9.—Mixing with Water*

in the preparation of the durability specimens and in the construction of the field experiments.

In general the laboratory mixtures of each soil were made with 2, 4 and 6 per cent cement by oven dry weight of soil. Specimens of soil-cement mixtures about 1½ in. in diameter and 2 in. high were drilled from the larger specimens compacted at the optimum moisture content in the Proctor mold immediately after it was formed. These specimens were allowed to harden in air at the laboratory for seven days and then subjected to repeated wetting and drying by submerging them in water at 70 degrees F. for 18 hours and then drying them in an oven at 110 degrees F. for 8 hours. They were then allowed to cool in air, brushed lightly with a wire brush, weighed and the cycle repeated. After 15 such cycles the losses were very small. Based on this information and on the cement contents used in the experiments previously constructed, it was decided to add 6 per cent by weight of cement in most of the field experiments but 4 per cent was considered sufficient for 2,500 ft. These quantities were increased to 7 and 5 per cent respectively to compensate for losses which might occur in the field.

The laboratory work was continued on the same specimens by subjecting them to repeated freezing and thawing tests in the following manner: They were dried in an oven at 300 degrees F. for 15 hours, immersed in water at 70 degrees F. for 8 hours and placed in a refrigerator in which the temperature was 20 degrees F. for 16 hours. They were then removed and allowed to thaw in air for 8 hours, dried as before, brushed lightly and weighed.

In Figure 1, information on a typical sample of soil from this project is shown. This includes the partial analysis of the soil, the Proctor density curves, and the curves plotted from the results of the durability tests.

*Construction of Field Experiments.*—Construction of the field experiments was started on September 17, 1935, but the last section was not completed until November 21. Approximately 4,800 ft. of the experiment were constructed 6 in. thick and 3,000 ft., 4 in. thick. All of it is 22 ft. wide. The experiment was constructed in ten sections each approximately 800 ft. long.

It was not possible with the equipment available to carry out the work so that a section could be finished during daylight, and a description of the best method developed on this project is as follows:

Step 1.—The untreated soil was first scarified and then pulverized with a disc harrow until there were no lumps larger than 1 in. in diameter.

Step 2.—Cement was spread on the surface of the pulverized soil with a sand spreader attached at the back of a truck. Time was lost in changing the spreader from empty to loaded trucks.

Step 3.—After the surface was covered with cement, it was disced with the machines operated very slowly so as to partially cover the cement. This operation must be carefully done as cement may be deposited below the loose soil if the discs are not properly set.

Step 4.—Mixing was done with a 12-ft. road machine and a multiple blade drag with a 20 in. mold board. These machines were operated so that the drag mixed the roll of material turned up by the road machines. In order to moisten the mixture uniformly for a 6 in. depth, it was necessary to store part of it on the shoulders, moisten that remaining in the road, and then bring in the stored material and moisten it.

Step 5.—Water was applied with an asphalt distributor.

Step 6.—As water tends to distribute itself, mixing was readily accomplished with a disc harrow and it was unnecessary to use other mixing equipment. This discing loosened the mixture for the full depth and permitted the feet of the sheeps foot roller to begin compaction uniformly at the bottom of the mix.

Step 7.—This picture shows the equipment used for determining moisture contents in the field.

Step 8.—When the moisture content, as determined by the above mentioned method, was approximately correct, compaction with the sheeps foot roller was started. The feet of the roller would not leave a smooth surface, and it was necessary to fill the depressions by blading the surface and the mulch thus formed was rolled with loaded trucks.

Step 9.—The finishing operation consisted of blading the surface to the correct grade and cross-section with a hand operated road machine. This work was partially done during compaction and completed before the trucks had finished rolling the surface.

Step 10.—This illustration shows the completed road after the application of the temporary wearing course.

"Turn Arounds": The connection between sections, called "Turn Arounds" by field men were a constant source of trouble on this project as the equipment, especially that used for mixing and compacting, was turned around each time the end of the section was reached. It was realized that failures due to non-uniform mixing as well as insufficient depth would be likely to occur here.

*Wearing Course.*—Portions of the previously constructed soil-cement experiments had not been surfaced so that they would be exposed to traffic and wear on these sections had shown the desirability of using a wearing course to give a smooth riding surface and prevent pot-holes and excessive wear. It was impossbile, due to cold weather, to construct a satisfactory wearing course on this project when the last section was completed and a temporary wearing course of cut-back asphalt and sand was applied. This was followed approximately seven months later with a one-half inch mixed-in-place bituminous wearing course.

Approximately 150 ft. each of four sections were not surfaced at the request of the Portland Cement Association so as to learn the effect of traffic on the unprotected cement-hardened mixture.

*Condition of Field Experiments.*—Only two defects, not over 10 sq. yds. in area, due to poor construction, have developed. After six months' exposure to traffic, the unsurfaced areas showed the effect of traffic by scattered areas of pot-holes and scaling not over 2 in. deep, but in many places down to the part compacted by the sheeps foot roller. On Section 7, marks from tires of trucks used in rolling the top mulch were still visible.

*Fig. 10.—Determining Moisture Content*

*Fig. 11.—Compacting*

*Fig. 12.—Finishing*

*Fig. 13.—Finished Road*

*Cost of Construction.*—The cost of constructing the soil-cement base was $0.384 per square yard of which amount $0.168 was spent for labor, gas, oil and repairs and $0.216 for cement. No rent for equipment is included in these figures.

## Loris Experiment

Study of this method of soil stabilization was continued by the department with the construction early last summer (1936) of the Loris Experiment which is two miles long.

The cement content was determined in the laboratory by the same methods used for the Johnsonville Experiment with slight modifications. As a factor of safety, the quantities chosen from the results of the durability tests were increased by 25 per cent.

Plans for this project were to construct a base course consisting of 6 in. of compacted soil-cement mixture using the soil in the road-bed and to cover this base, before it was exposed to traffic, with a bituminous wearing course approximately ½ in. thick. As constructed each section was approximately 1,000 ft. long and all sections except one, were finished in less than 12 hours.

For the Johnsonville experiment, a total of 66 calendar days elapsed from the beginning to the completion of the construction of the 7,850 feet of base course, but for this project only 22 calendar days were required for construction of 10,930 lin. ft. of base. This increase in the rate of construction was the result of better coordination of the different operations, better equipment for spreading cement, and more powerful equipment for mixing.

The wearing course was applied nineteen days after all the base was completed. At that time the base appeared to be in excellent condition throughout the project

*Fig.* 14.—*Traveling Plant Picking Up Windrow*

*Fig.* 15.—*Dumping Cement in Measuring Hopper*

and no defects have been discovered on subsequent inspections.

Both the Johnsonville experiment and this project were constructed under the same labor provisions. The cost of constructing this base course was 36.8 ct. per square yard, of which 4.9 ct. were spent for labor, 6.0 ct. for gas, oil and equipment repairs and 25.9 ct. for cement. No rent for equipment is included in these figures, but for the equipment used this cost would amount to approximately 0.7 ct. more per square yard.

## State Project 368-B—Hampton County

Construction was started recently on the first cement stabilized base which has been let to contract. This project is ten miles long and to date approximately three miles of the base have been completed. The plans require a completed cement-soil base 22 ft. wide and 6 in. thick, and an average application of .10 bbl. of cement per square yard which is equivalent to approximately 7 per cent by weight. The cement content is adjusted, however, to suit the soil encountered and is based on the results of laboratory tests.

The project was graded in the normal manner without special selection of soil for the top and the material which is to be mixed with cement varies from almost pure sand to a gumbo type clay soil.

The contractor is using a traveling mixing plant instead of the mixed-in-place method used in previous work of this type. The soil is pulverized then windrowed in the road. It is elevated to a bin on the traveling mixer and flows by gravity through a measuring gate to the pug-mill. If necessary to raise the moisture content to the optimum figure for compaction, water is

*Fig.* 16.—*Compacting Plant Made Mixture*

*Fig.* 17.—*Finishing the Road*

added just after the soil leaves the measuring gate. The measured quantity of cement is added when the soil enters the pug-mill and both measuring gates are connected so that neither the quantity of soil nor cement can vary appreciably. Apparently the pug-mill does an excellent job of mixing.

The mixture is spread by hand labor to the required cross-section and it is compacted by a sheeps foot tamper worked back and forth over the surface. As this machine does not leave a smooth surface, the mix is also rolled with loaded trucks. The surface is finished to approximate grade and cross-section with a mechanically operated motor patrol, and then planed to the exact lines with a blade drag.

So far, it has not been found necessary to "cure" soil-cement mixtures. Some laboratory tests, however, indicate that proper curing would add materially to the strength and to the resistance to freezing and thawing of such mixtures.

At the present time, the experience in South Carolina with soil-cement mixtures indicates that, with proper preliminary laboratory work such as described herein, and careful attention to field construction, especially adequate compaction, stabilizing soil with portland cement is practical and comparatively economical.

*Credit.*—Acknowledgment is gratefully made to the Portland Cement Association for its cooperation on some of the early field experiments and especially on the Johnsonville experiment. The development department of this association not only assisted financially on this project, but presented a plan for the laboratory and field work which was adopted. Mr. M. D. Catton, who represented the association, rendered assistance of tremendous value during all of this work.

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## Gas Tax Diversion in New York

A study of New York state's road financing and tax policies, made in advance of a public hearing to be held at Albany, N. Y., March 3, on proposals to increase the state gasoline tax to 4 ct. a gallon and to divert the larger part of motor tax revenues to general purposes, reveals that the state has been spending for state highways only one-half as much per vehicle as in 1929, but is diverting to general purposes more than 10 times as much. While there has been an increase in expenditures for local roads, total road expenditures are far below special additional motor tax collections.

The study of the New York situation, made by the American Petroleum Industries Committee, indicates that New York's expenditures for state highways have declined from $18.30 per motor vehicle in 1929 to $9.36 per motor vehicle, in 1935, the latest year for which data are available. The use of motor tax revenues for general purposes has increased from $2.06 per motor vehicle in 1929 to $25.12 per vehicle in 1935.

In the same period the cost of gasoline taxes per vehicle per year increased from $8.42 in 1929 to $24.22 in 1935. Registration fees per vehicle increased from $16.91 in 1929 to $18.19 per vehicle in 1935. Total taxes per motor vehicle increased from $25.34 in 1929 to $42.97 in 1935.

Although data on highway expenditures and diversion in 1936 are not available, the cost of gasoline taxes per vehicle are estimated at $22.57, the decline from the $24.22 cost of 1935 reflecting the gasoline tax reduction from 4 ct. to 3 ct. per gallon. Registration fees are estimated at $18.19 per vehicle in 1936, making a total tax cost per vehicle of $40.76.

## Weed Control and Eradication on Roadsides

A very complete discussion of the above subject is given in the February Public Roads. In fact the entire issue is devoted to a study of present practices and their practical application. The article concludes with the following summary:

Marked progress has been made in the control of weeds on our highways. Each year weeds are cut or killed by various treatments along a large mileage of road but the work is still in the transition stage. There is already available a variety of methods most of which are suitable for control work in any part of the United States. Improvements will undoubtedly be made in the existing methods and new ones will be discovered but effective control is now possible with the weapons already at hand.

The most important recommendation to be made at this time is that all work be done as part of a permanent-control policy with particular emphasis on the prevention of new weed growth. Cutting weeds or killing them by other methods should not be regarded as a job to be done at some convenient time to remove unsightly objects but as a job that must be done at such times as will prevent reproduction. The major part of the problem is to prevent reseeding but some special attention must be given weeds that propagate from root growth.

Elimination of reproduction is important not only because it will make possible diminishing expenditures for control but because it is the only method by which the highways can be given the appearance of being well kept at all times.

Machine mowing is the most generally used method of weed control. In general, the costs per acre by this method are lower than by other methods. However, machine mowing is not a complete method in itself and must be supplemented by methods that are effective at places not reached by the mower. It is important that effective work in mowing not be vitiated by seed from places not reached by the machine.

Modern cross-section design with slopes that can be reached by a mowing machine and side ditches that can be mowed over greatly increase the effectiveness of machine mowing.

Burning is practiced largely to dispose of cut or killed weeds. Oil and sodium chlorate are the materials that have been applied most often as weed killers in highway work, and are effective. They are useful for general applications and as supplements to mowing to kill weeds not reached by the mower.

Every state highway department should decide upon a definite policy of weed control, equip its forces in accordance with the methods selected and fully instruct its maintenance personnel why and when different operations must be performed. The character of the work and the time it should be done will vary from year to year depending upon the effectiveness of the work of preceding years and how the weather affects the maturing of weed growth.

The objective should be the replacement of all weeds with suitable low growth. Most highway departments now have a landscape architect to supervise roadside-improvement work and his knowledge of plant habits and growth makes it desirable that he have close contact with the planning of weed-control work.

*Construction View of Composite Laminated Timber—Concrete Bridge Over Mill Creek, Near Dover, Del.*

# COMPOSITE TIMBER-CONCRETE DECKS FOR HIGHWAY BRIDGES

By W. D. KEENEY
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HIGHWAY bridge decks of concrete supported by stringer systems and bents of creosoted timber have been used in many sections of the country for a number of years past. It is only within the last five years, however, that composite types have been employed in which treated timber and concrete are combined to form homogeneous stress-bearing members. Two types of composite beams or slabs have been developed and used for highway bridge decks after carefully planned laboratory tests made to determine the practicability of combining the two materials in articulated construction and to establish a correct theory for the design of such members.

The most comprehensive of these tests were made by the Oregon State Highway Commission during the summer of 1932, when a research project was undertaken at the Oregon State College. The beams tested consisted of a timber joist to which was attached a flange of portland cement concrete, forming essentially a T-beam.

A preliminary study of the type had indicated several advantages. One was that the concrete slab frequently used on timber stringers could be made to act as a T-beam flange for each of the timber stringers if reliance could be placed on the mechanical bond or shear connection introduced between the two materials at their junction plane. Beams in the test were of two sizes. The smaller beams had 6 by 15-in. concrete flanges and 4 by 14-in. timber webs, while the larger beams had 6 by 24-in. flanges and 6 by 15-in. webs. Various devices were used for the shear connection between the flange and the web. These included spikes alone as well as in combination with daps in the stringer top, short pieces of 2½-in. pipe used as dowels, and small steel plates set in kerfs cut in the contact edge of

*Another Construction View of Mill Creek Bridge, Near Dover, Del.*

*Timber Portion of Deck Slab in Place, Duval County, Florida*

the stringer. The pipe dowels and the combined spike and daps produced the best results, the spike and dap method presenting an advantage over the dowels of greater economy in first cost.

The tests showed the ultimate strength of a composite beam of this type, suitably designed and effectively connected at the junction plane, to be at least twice that secured when the same dimensions and same materials were independently employed. They also showed that the deflection of a composite beam under a given loading will not be more than 25 per cent of the corresponding deflection for the same sizes of materials used independently. Five of the beams tested under loads repeatedly applied and released indicated no appreciable loss of strength as a result of the repeated loads. To determine the effect of temperature changes, two beams were subjected to alternate freezing and thawing. Thermal changes did not induce sufficient stresses to cause concern but were of sufficient magnitude to warrant definite provisions for them in the design of the shear connection.

The second complete type, which is a slab, was developed shortly after the Oregon tests were made. Tests were made on this type at George Washington University during the summer of 1933. The timber, or the tension portion, was built up of vertical laminations of thin plank spiked together with their edges so disposed that maximum efficiency would be secured from the beam in strength and stiffness. The upper edges of alternate laminations are raised 2 in., thus forming longitudinal grooves 2 in. in depth by from 1⅝ to 1¾ in. in width, since the laminations were dressed 2-in. plank. Into these longitudinal grooves thin triangular metal places called shear developers were driven to engage the corners of the raised laminations as well as the top of the intermediate depressed laminations. The shear developers were stamped from 3/32-in. steel plates and their base was left to protrude ½ in. above the upper laminations to engage the concrete mat and develop horizontal shear between the two materials. Tests indicated that the effective depth of properly designed slabs is equal to the combined thickness of the two materials and that virtually the strength of a homogeneous beam or slab could be developed.

This type of slab utilizes a size and grade of lumber easily obtainable at low cost, and the thin strips permit effective preservative treatment. A considerable degree of continuity can be achieved in this type, as a sufficient number of strips can be carried unbroken across the support to provide for negative moment when the superimposed concrete mat is reinforced for tension over the bents.

A considerable number of structures have been built using each type of composite deck. More than 100 structures of the type developed by the Oregon Highway Commission have been built on the highway system of that state. The first bridges of this type have now been in service about five years. Individual span lengths are generally from 15 to 30 ft., though span lengths up to 40 ft. have been used.

The composite slab type deck with shear developers was first used on a bridge built across Tampa Bay in 1933 as a part of a 9-mile causeway project. This bridge is 3,200 ft. long, with span lengths of 20 ft. There are also two shorter bridges of the same type on this project near the shore lines. One is a 14-ft. single span bridge, and the other is a 310-ft. bridge consisting of 20-ft. spans.

More recently several bridges in different parts of the country have been designed with decks of this type for the H-15 truck loading. Fourteen structures have been completed or are under construction. These bridges have span lengths of 20 ft., and the slab bases are generally built up of 2 by 8-in. plank with alternate laminations raised from 1¾ to 2 in. above the intermediate laminations. Short blocks are used as fillers across the cap under the raised 2 by 8s. In the case of the Tampa bridge, however, 8-in. and 10-in. depths were alternated. Joints in the laminations are usually made at the quarter points of the span and over the caps, two-thirds of the pieces being thus continuous at any of these sections. The concrete portion of the slab contains sufficient reinforcing steel to provide for temperature and shrinkage stresses only, except in continuous spans, where negative reinforcement is required also over the supports.

The composite types are adapted to structures where individual span lengths are similar to or only slightly longer than those used in trestle construction. Short span structures, however, constitute the major portion of bridges on most highway systems. Figures published by the highway department of the State of Oregon show that of a total of 100,673 lin. ft. of bridging on primary highways, 51,643 lin. ft., or 51.3 per cent, comprise structures having individual span lengths less than 30 ft. The concrete mat provides a high type of wearing surface and, when rigidly connected with the stringers or timber portion of the slab, adds materially to the strength and rigidity of the span.

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*Seven Hundred and Fifty-six Register at Purdue Road School.*—The 23rd Annual Purdue Road School, held Jan. 25-29, had a registration of 756, an increase of 30 over the previous year. The registration by classifications was as follows: State highway commission, 150; county road supervisors, 40; other county road employees, 77; county surveyors, 63; assistant county surveyors, 8; county commissioners, 85; city officials, 28; contractors, 35; materials and equipment men, 197; miscellaneous, 73.

# HOW UNUSUAL INTERSECTION PROBLEMS AT WASHINGTON, D. C. WERE HANDLED

By W. A. VAN DUZER

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*Walk Signal at 12th and F Sts., N.*

EACH city, as the result of the street plan, man-made obstacles to traffic flow, natural barriers, uncontrolled growth, park areas, traffic density and other factors, has its own peculiar intersection problems. Washington, D. C., probably more than any other city is faced with out-of-the-ordinary intersection problems.

Pierre Charles L'Enfant stated in his Observations Explanatory of the Plan for the City of Washington that "the positions for the different grand edifices and for the several grand squares or areas of different shapes, as they are laid down, were first determined on the most advantageous ground commanding the most extensive prospects." Thus, the Capitol was located on the highest hill and the White House provided with a beautiful vista down the Potomac River. From these central points a number of wide radial avenues were planned to give quick and easy access to the outlying portions of the city. L'Enfant's familiarity with Versailles is illustrated by the many diagonal avenues in the plan which he produced. The rest of the streets of the city were laid out on the gridiron system, the streets running either directly north and south or east and west.

This plan of diagonal and radial avenues superimposed upon a gridiron system of streets forms many multiple intersections and caused the introduction of many circles and squares. The Capitol and Library of Congress on the east and the White House and Treasury on the west were built on the line of the principal avenue.

All of the main streets of the city are subject to one or more such obstacles, diverting traffic to circuitous routes to get back on the main thoroughfare, causing many turning movements at surrounding intersections and abnormal divergence of traffic.

The following text and illustrations give the treatment of several of the unusual intersections encountered in the City of Washington, together with a pedestrian control installation.

## First Pedestrian "Walk" Signal Installed

On May 13, 1936, the first pedestrian "Walk" signals in the District of Columbia were installed at 12th and F. Streets, N.W., in the heart of the downtown district. This was the first attempt to provide, in the City of Washington, the man on foot with a definite indication just when he should cross the street.

Twelfth and F Streets, N.W., is the second heaviest pedestrian intersection in the City of Washington with an average of over 45,000 pedestrians on each day for the seven hours, 8:00 to 12:00 and 3:00 to 6:00 p. m. Figure 1 gives diagrammatically the signal indications and movements permitted at this intersection. Vehicular traffic is controlled by arrow signals and left turns are prohibited.

On this plan the first indication following the red is a double arrow indication permitting straight through traffic and right turn traffic. After 14 seconds the right turn arrow is turned off and the "walk" indication appears. Pedestrians are told by signs to start only while "walk" shows. After the "walk" signal is extinguished, sufficient time remains for a pedestrian walking at the rate of 4.5 ft. per second to cross the street before the signal changes to red. In this way pedestrians who obey the signal are afforded absolute protection while crossing the street with no danger of being trapped in the center of the street at a change of signal.

A cycle of 80 seconds was chosen as the shortest feasible to provide for the right-turn period, the pedestrian clearance period, and allow the collected pedestrians to step from the curb.

The "walk" signals are home-made, using letters 3 in. high with a stroke of 5/16 in. The signals are painted gray as is the painted portions of the glass so as to approach the color of the unpainted portions of the glass. This gives a sharply defined "walk" indication when burning and the letters spelling "walk" are scarcely distinguishable when dark.


*Signal at 12th and Constitution Ave. N. W.*

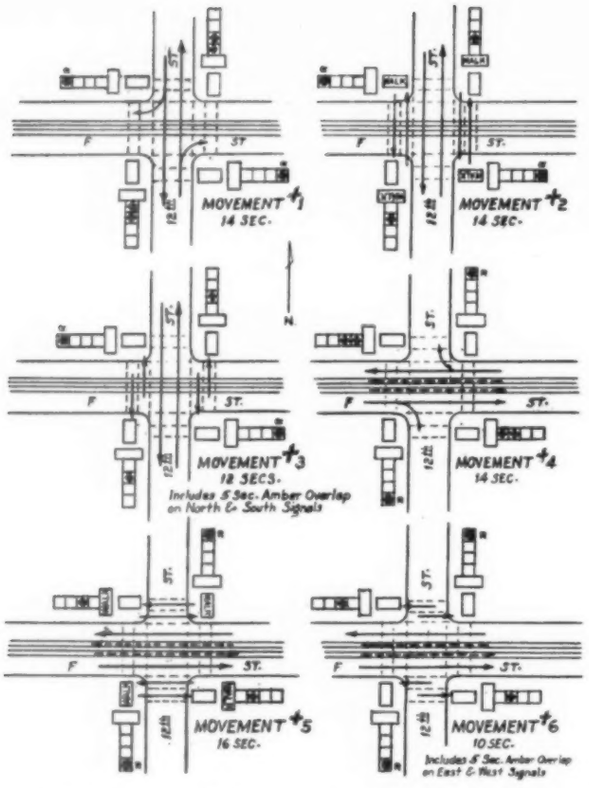



*Fig. 1—Traffic Control Pedestrian Signals, 12th and F St., N. W.*

Two surveys of pedestrian observance of these signals returned the following:

| Signal Indication | — 5-20-36 — Number | Pct. | — 5-29-36 — Number | Pct. |
|---|---|---|---|---|
| Pedestrians step from curb on— | | | | |
| Straight through and right turn arrow | 20,270 | 42.5 | 24,192 | 46.9 |
| Walk and straight through arrow | 12,938 | 27.1 | 14,081 | 27.3 |
| Straight through arrow | 5,274 | 11.2 | 5,863 | 11.4 |
| Red | 9,161 | 19.2 | 7,442 | 14.4 |
| Total | 47,643 | 100 | 51,578 | 100 |

Although pedestrian use of the "walk" indication was not as high as had been hoped, however, a smaller percentage of the pedestrians used the red indication. Two former surveys, one in 1934 and one just prior to the "walk" signal installation in 1936, returned respectively 32.1 per cent and 32.3 per cent of the pedestrians crossing against the red signal.

## 15th and H Streets, N. E.

Fifteenth and H Streets, N.E., is an outlying intersection at the junction of the two main exits from the City of Washington to the Maryland residential districts to the northeast of the city and to the Maryland beach resorts. At all times it is subject to large volumes of traffic and wide variations in volume and direction of volume. During the summer months this condition is especially extreme.

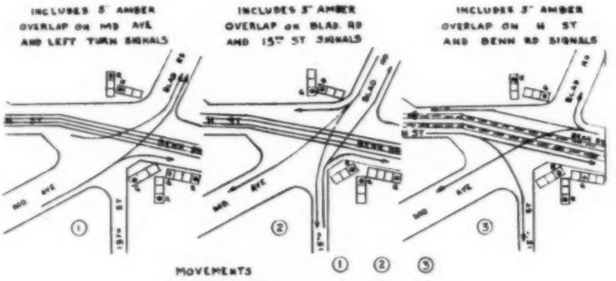
Figure 2 is a flow map of this intersection. Bladensburg and Benning Roads are the highways leading into Maryland.

The plan for control of this intersection, chosen as the most effective, consists of a three-phase program timer. This timer permits a basic time period with a time extension for each phase. The timer permits 70 changes in time per week, 10 for each day of the week. Volume and direction counts made for 24 hours for each day in the week served to compute the basic and time extension periods and the correct hours for the insertion of each time extension. As the timer only allows two timings for each phase, that is, a basic period and a maximum period, the maximum period for each phase was computed as the least number of seconds required to handle the traffic on that phase when traffic on all three phases was maximum. This gave the maximum time cycle and the maximum period for each phase. Using this maximum cycle, the basic period for each phase was computed as the least number of seconds required to handle the traffic on that phase when the other two phases received maximum time. This gave the minimum time cycle and the difference of the maximum and minimum for each phase gave the time extension periods. The time extension periods were then inserted or rejected at the proper hours revealed by the traffic counts.

Figure 3 is a plan of the movements allowed on each phase and the program of timing for each day of the week. This control was installed November 21, 1934, and has since operated with a high degree of efficiency.

## 12th and Constitution Avenue

Constitution Avenue, forming the south boundary of the Federal Triangle, is 80 ft. wide. Lying for the larger portion of its length within the Public Parks System and just south of the Central Business District,




| TIME OF CHANGES | SUNDAY 1 | 2 | 3 | MONDAY 1 | 2 | 3 | TUESDAY 1 | 2 | 3 | WEDNESDAY 1 | 2 | 3 | THURSDAY 1 | 2 | 3 | FRIDAY 1 | 2 | 3 | SATURDAY 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6:30 AM | | | | ON | | | ON | | | ON | | | ON | | | ON | | | ON | | |
| | | | | 15 | 34 | 23 | 15 | 34 | 18 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 |
| 8:15 AM | | ON | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 18 | 15 | 34 | 18 | 15 | 34 | 18 | 15 | 34 | 18 | 15 | 34 | 18 | 15 | 34 | 18 | 15 | 20 | 18 |
| 9:30 AM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 23 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 |
| 11:00 AM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 34 | 23 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 23 |
| 1:00 PM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 23 |
| 4:00 PM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 18 | 27 | 34 | 23 | 27 | 34 | 23 | 27 | 34 | 23 | 27 | 34 | 23 | 27 | 34 | 23 | 15 | 20 | 23 |
| 5:30 PM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 18 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 20 | 23 |
| 7:00 PM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 | 15 | 34 | 23 |
| 10:30 PM | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 | 15 | 20 | 18 |
| 12:30 AM | OFF | | | OFF | | | OFF | | | OFF | | | OFF | | | OFF | | | OFF | | |

MONDAY TO SATURDAY: FLASHES AMBER - 12:30 AM. TO 6:30 AM
SUNDAY: FLASHES AMBER - 12:30 AM. TO 8:15 AM

*Fig. 2—Program of Timing and Movements, 15th Ave. and H Sts., N. E.*

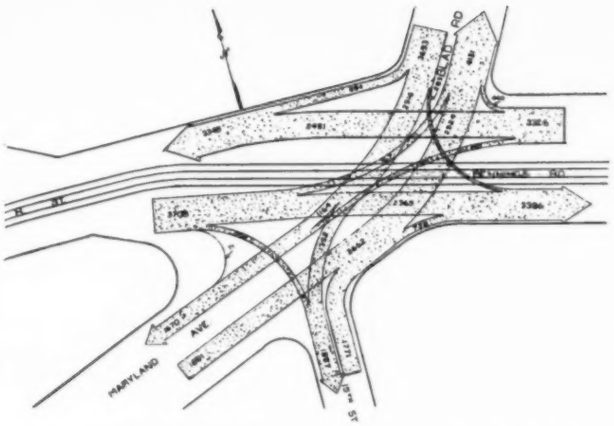



*Fig. 3—Traffic Flow, 15th and H Sts., N. E., for Hours 8 to 11 a. m. and 3 to 6 p. m. Total Traffic,* 14,389.

this street is not heavily pedestrian traveled and is a high speed by-pass around the Central District.

The intersection with 12th Street presented the main problem, Traffic flow at this intersection is shown in Fig. 4. The original signal plan used was the simple two phase on a 65 second cycle providing an 18 second headway at 22 m.p.h. over Constitution Avenue, and split 30 seconds and 35 seconds respectively at 12th and Constitution Avenue. This was most ineffective during the peak hours and caused a "backing up" on Constitution Avenue for over 500 ft. in each direction for an hour in the morning and an hour in the afternoon. The principal cause of this congestion was the interference with and the slowing up of the through Constitution Avenue traffic by the left turns "jockeying" their way from the avenue into 12th Street. The westbound to southbound left turn was the most troublesome for a heavy busy line followed that path.

To eliminate the left-turn interference a three-phase timer was installed giving single entry on Constitution Avenue and double entry on 12th Street. At the same time the cycle on the system was increased to 80 seconds and the signals along Constitution Avenue co-ordinated for 27 m.p.h. with a 30-second headway. At 12th and Constitution Avenue eastbound was given 30 seconds, westbound 30 seconds and 12th Street 20 seconds. Some improvement was noted on Constitution Avenue, but the problem was in no sense solved for the "backing up," although to a much lesser degree, still took place on Constitution Avenue. Twenty seconds proved too short for northbound 12th Street traffic, composed to a large extent of slow moving trucks from the wharves and market areas to the south.

Some means to provide a greater number of seconds for each movement while maintaining the same cycle had to be devised. First, 12th Street south of Constitution Avenue was painted to provide three northbound lanes and one southbound lane. On July 15, 1936, the present four-phase control was installed. This control gave a single entry eastbound, followed by double entry east and west, then single entry westbound, followed by the 12th Street movement. The Constitution Avenue movements are controlled by arrow signals and Fig. 5 illustrates this plan. This entirely eliminated left turn conflicts on Constitution Avenue while providing ample time for left turns and increased the total time for through movement in all directions. The co-ordination at 27 m.p.h. with a 30-second headway was maintained.

Congestion at once disappeared. Formerly between 4:00 and 4:45 p. m. an average of 54 cars in the eastbound direction on Constitution Avenue were observed "backed up" on each change of signal with an average of 41 cars clearing the intersection on the following green signal and the eastbound direction returned an average of 57 cars "backed up" and an average of 35 cars clearing the intersection on the following green signal. In other words, every car approaching this intersection during this peak period had to wait through one or more complete changes of cycle and none were passed instantly through the intersection. On the present system of signals during the same time period for the eastbound movement, an average of 17 cars have been observed standing on the red light with an average of 45 cars clearing the intersection on the next green. The westbound direction returned an average of 21 cars standing on the red with an average of 41 cars clearing the intersection on the following green. As high as 65 cars in one direction on Constitution Avenue with 48 cars north on 12th Street have been observed clearing the intersection during one signal change. The present installation increased the capacity of the intersection, passed the traffic through more nearly as it presented itself and on the whole has proved a very satisfactory solution of the problem.

## 15th Street at G Street and New York Avenue, N. W.

For years the intersection of 15th and New York Avenue, N.W., has been a sore spot with every motorist and pedestrian who came in contact with it. This intersection is on Pennsylvania Avenue at the northeast cor-

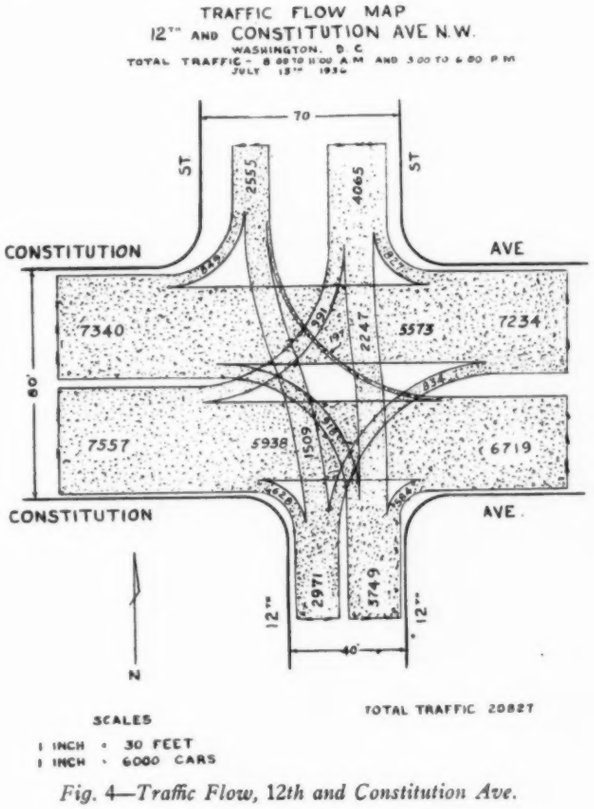



*Fig. 4—Traffic Flow, 12th and Constitution Ave.*

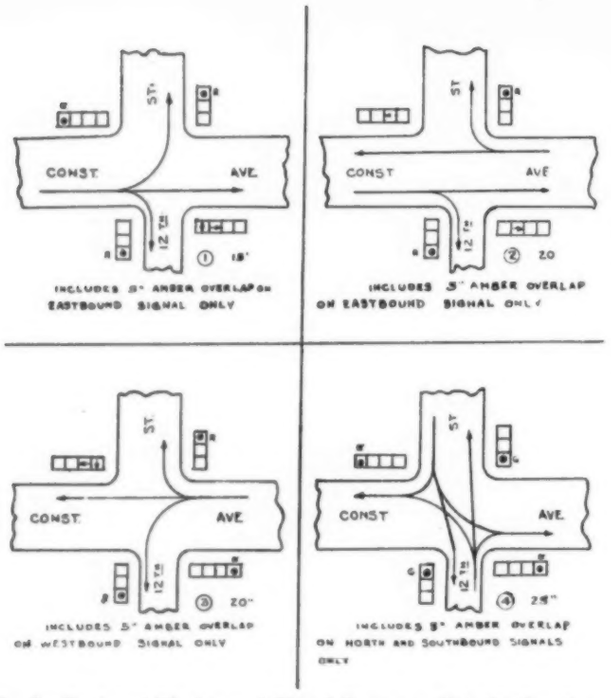



*Fig. 5—Proposed Timing and Signal Sequence, Constitution Ave. at 12th St., N. W.*

ner of the Treasury Building. It carries heavy volumes of pedestrian, automotive and street car traffic. The former complicated street car turning movements made an efficient control method impossible. The old control was two-phase manually operated. All left turns were prohibited and all traffic eastbound was forced to turn right from Pennsylvania Avenue south into 15th Street. This caused turning movements at other intersections, interrupted a fine route from the west to the east ends of the city and left the heavy pedestrian volume on the south crosswalk without protection.

During the first months of 1936 street cars in Washington were re-routed and the tracks from 15th Street north to east on New York Avenue were eliminated. This simplified the problem somewhat, but new tracks built from 15th Street into G Street caused new complications.

On August 9, 1936, the present traffic control was installed and Fig. 6 gives the present layout and traffic flow. At 15th and New York Avenue one left turn is allowed, eastbound traffic is permitted to proceed straight through the intersection and the south crosswalk is fully protected.

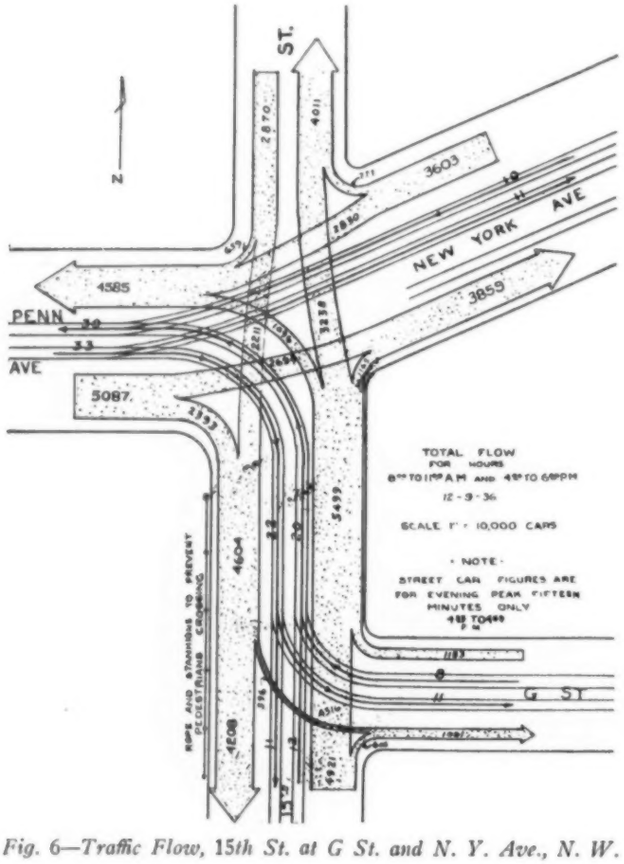



*Fig. 6—Traffic Flow, 15th St. at G St. and N. Y. Ave., N. W.*

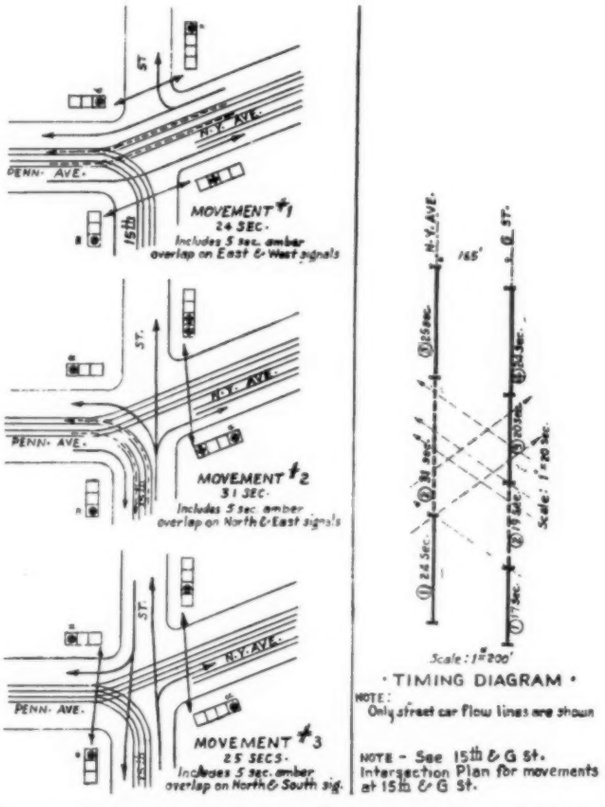



*Fig. 7—Traffic Control Signals, Signal Sequence and Timing Diagram, 15th St., N. W., at N. Y. Ave. Date in Service, 8-9-36.*

The control at 15th and New York Avenue is three phase and Fig. 7 gives the movement on each phase. As movement No. 2 on Fig. 7 is the northbound street car movement and due to a cut-out, there is room for but one street car to stand between New York Avenue and G Street, the signals at G Street had to be so arranged that those northbound on 15th Street and those westbound on G Street moving on different phases would pass the intersection at New York Avenue on the same phase. This was accomplished by dividing the 80-second cycle (the cycle for the downtown system of flexible progressive signals) into four phases at 15th and G Streets, with street cars moving north on only two of them. Figure 8 gives these movements. A

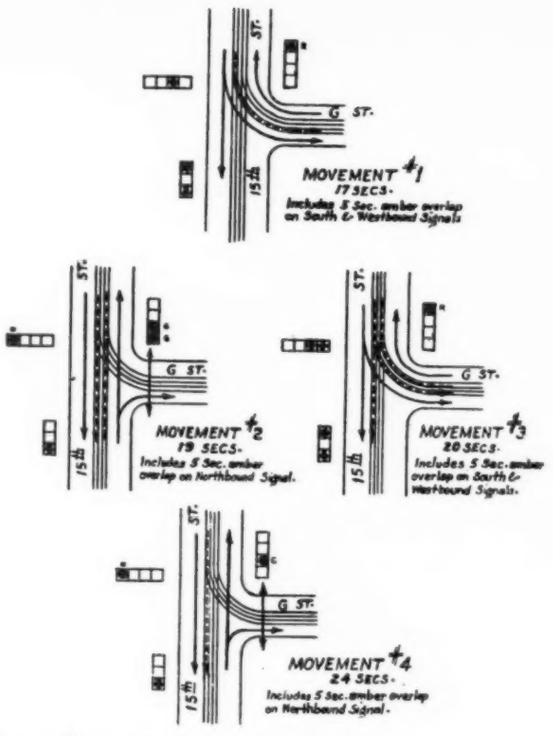



*Fig. 8—Traffic Control Signals and Signal Sequence, 15th St., N. W., at G St. Date of Service, 8-9-36.*

double green signal at 15th and G Streets northbound and two right turn arrows westbound differentiate the street cars' phases from the other two. Street cars through these intersections run on an 8-second headway and although very seldom do two street cars, either north on 15th Street or west on G Street, present themselves at the same time, the arrangement provides enough headway to care for that condition.

Automotive traffic moves as shown on Fig. 7 and 8. Southbound traffic at 15th and G Streets is uninterrupted and the timing diagram on Fig. 2 gives the timing relation between the two intersections.

## 11th and Pennsylvania Avenue, N. W.

The section of Pennsylvania Avenue lying between the Capitol and the White House is the widest street in the City of Washington, measuring 107 ft. from curb to curb. This street also carries a daily traffic volume greater than any other street in the city. The buildings

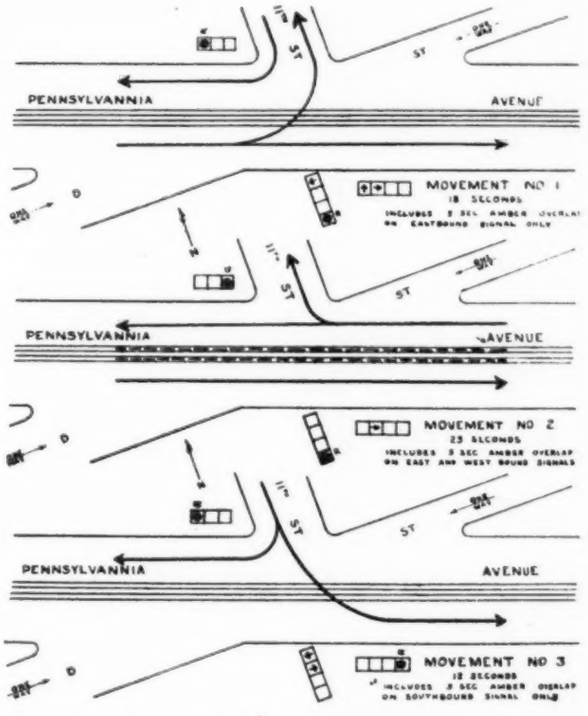



*Fig. 10—Traffic Control, 11th and Pennsylvania Ave., N. W. In Service, 12-4-34.*

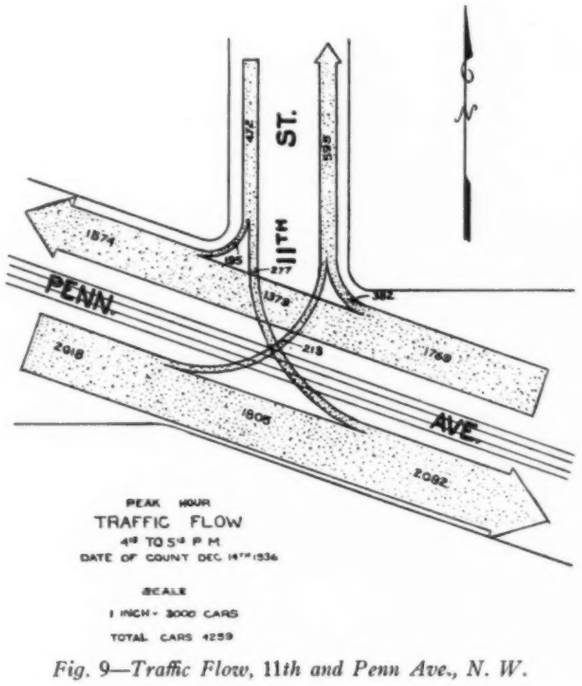



*Fig. 9—Traffic Flow, 11th and Penn Ave., N. W.*

of the Federal Triangle stand along the south curb and the main shopping center is to the north.

Of the eleven signal controlled intersections, four required multiple movement control. These intersections are Pennsylvania and Constitution Avenues, measuring 680 ft. at its widest point, controlled by two secondary timers, and the three intersections at 11th Street, 13th Street and 15th Street.

The intersections at 11th and 13th Streets are T-intersections, controlled by three-phase timers. Figures 9 and 10 illustrate the traffic flow and movements allowed at 11th and Pennsylvania Avenue.

All intersections along this section of Pennsylvania Avenue are co-ordinated at a speed of 20-22 m.p.h. on a 55-second cycle during the non-rush hours. In the rush hours a 70-second cycle is used which reduces the speed to that which can be maintained by the increased volume. These cycle changes are automatically produced at the proper hours by a time switch and an auxiliary master timer.

# Spring Breakups in New England

*At the left, a reminder that road builders still have something to live for. In spite of a sign, "Dangerous—Closed," the editor attempted to go through on this unimproved road near Modus, Connecticut, but turned back to save his car. It's easy to forget the great mileage of this sort of thing still to be found in all parts of the country on roads of lesser rank, but roads nevertheless important to local traffic. The one here shown was scheduled for improvement in the next few months.*

*The light bituminous surface below was on the outskirts of Stamford, Connecticut. Examination of broken spots indicated a thickness of less than two inches of stone with a binder which was soft and plastic, even in the cool weather of early spring. Excellent smooth stretches each way from this spot indicated poor drainage as the source of trouble. The road was on a good grade with a subsurface of yellow clay.*

*Both pictures were taken by the field editor of* ROADS AND STREETS *in March,* 1936.

# RECENT DEVELOPMENTS IN BITUMINOUS ROAD MATERIALS

## *A Review of the Patent Literature for 1931-1936*

By GEORGE W. ECKERT and H. F. WINTERKORN

*Missouri State Highway Department, Jefferson City, Missouri*

THE developments in bituminous road materials since 1930 can be followed by a critical study of the patent literature. A study of this kind reveals advances which have been made to improve the properties of the bituminous materials and bitumen-aggregate mixtures, although it does not include the developments which have been made in testing of these materials. The objective of providing a road material which will satisfy the requirements of weathering and traffic conditions can be approached from a consideration of the chemical and physical properties of bituminous materials and aggregate alone, and from a consideration of the methods for the preparation of bitumen and aggregate mixtures of desired properties.

### Modification of Bitumen by Chemical Means

The principal method of altering the chemical properties of bitumen is by "blowing" with air. The leading developments in this process have been in controlling the conditions under which the process is carried out. The proportions of asphaltenes and asphaltic resins are increased by oxidation and the properties of the asphalts are thereby changed. Chlorine (1)* may be added to the air to give a product with lower susceptibility to temperature changes, or ammonia may be added (2) for the purpose of prolonging the "adhesive life" of the material. Bituminous substances may be blown in the presence of up to 3% of sulfuric acid along with such oxidizing agents as persulfates or perborates (3, 4) or with a mineral oil containing sulfur (5). Small amounts of fatty oils, resin soaps or siccatives may also be present (3, 4).

Sulfur as an oxidizing agent for bitumen was proposed as long ago as 1866, but is still receiving some attention. It can be used in finely divided form as in spent gas purification masses to improve tars (6) or in conjunction with sulfur dioxide together with catalysts such as the sulfides and oxides of P, As, Sb, Sn, V, Mo, and W(7) or with CaO and potassium chlorate (8). The sulfur can also be added to the bitumen-aggregate mixture which is then heated to a temperature below that at which substantial vulcanization of the bitumen would occur (9).

Bituminous materials, particularly tars, under certain conditions are liable to oxidize with resulting undesirable properties. The oxidation of tars in road mixtures can be prevented or retarded by the addition of nitrogenous bases and polymerized triglycerides followed by heating with or without other substances as organic bases, bone tar, fatty acid, pitch, etc. (10, 11), or by the addition of amino-alcohols or amino-phenols (12). The oxidation of asphaltic substances can also be retarded by the addition of about 0.1-5.0% of wood-tar pitch (14). With tars this retarding can also be effected by subjection to hydrogenation under conditions which will cause the addition of hydrogen and a slight transformation of the tar without appreciably reducing the oxygen content (13).

Bituminous materials treated with condensing agents such as $AlCl_3$, $ZnCl_2$, $FeCl_3$, or $H_2SO_4$ (15, 16, 17) are improved in their binding properties by the formation of polymerization products. The Friedel-Crafts type of reaction can be applied to tars by the addition of chlorinated aliphatic compounds of high molecular weight together with aluminum chloride (18, 19). China wood oil and a condensing agent such as ferric chloride or aluminum chloride can be added to asphaltic substances to improve their binding qualities (20) and vegetable oils, such as soybean oil, added to tars containing phenolic OH groups and heated with sulfuric acid improves their properties (21) with polymerization reactions accounting for the effects in both cases.

### Improvement by Addition of Organic Materials

The acid constituents capable of reacting with basic constituents of the mineral aggregate have been suggested as an important factor in the binding quality of asphalts. The acids may not only form water insoluble soaps at the asphalt-aggregate interface but they may also become oriented at the interface in such a way as to increase the stability of the mixture. Asphalts which do not contain an appreciable amount of acid constituents can be provided with such by the addition of substances containing humic acid (22, 23) or aliphatic acids such as oleic or stearic acid (24).

Instead of adding acids to the bitumen to react with the mineral, soaps can be added which become oriented at the mineral-bitumen interface to increase the adhesion of the bitumen. Such substances which can be added are heavy metal soaps of fatty, waxy, naphthenic or resinous acids (25), soaps of the metals of the fourth periodic group (26), calcium oleate (27, 28) or other metal oleates or stearates (29, 30, 31) sometimes in conjunction with sulfur. The addition of acetic acid and zinc oxide (33) may serve the same purpose.

The addition of rubber to bituminous materials has been shown to increase their hardness, raise their softening point, and increase their elasticity (37). For these reasons, the addition of rubber to bitumen for road purposes may be desirable in many instances and the use of rubber for such purposes has appeared in some recent patents. One composition for road binding contains a ratio of asphalt to rubber of 99:1 (34) whereas another contains as high as 50% rubber (35). Rubber-bitumen mixtures for road purposes can be prepared in several ways, one of which is to mix separate emulsions of rubber and bitumen (36). An aqueous emul-

*Figures in parenthesis relate to references at end of article.

sion can also be prepared by mixing molten bitumen and rubber latex in a colloid mill (38). Another method consists in suspending finely divided rubber in a liquid which does not dissolve the rubber, but which is completely miscible with the asphalt, and mixing the rubber-liquid dispersion with the molten asphalt (39). Suitable liquids are anthracene oil, creosote oil, heavy tar oil, paraffin oil, heavy lubricating oil, turpentine, and linseed oil. "Nitrite" rubber (40) and chlorinated rubber (41, 42, 43, 44) are finding use in this connection.

Various organic substances are claimed to improve the properties of bituminous substances used as road binders, such as polymerized polyvinyl chloride (45), fermented rice-bran treated with formaldehyde in a caustic alkali solution (47), naphthalene (48), and hydronaphthalenes (49). Phenol or alkali phenates up to 2% increase the fluidity of asphaltic materials (46). Resinates, sulfonates, naphthenates, or linoleates of heavy metals reduce or suppress the sticky nature of asphaltic materials (50).

## Blending

Blending of bituminous materials is an important factor in the preparation of binders having specified properties. Bituminous materials can be blended as such, in the form of emulsions, or after one or more of the constituents have been mixed with an aggregate or filler. A treatise of the general practices in blending has been given by Abraham (51). According to a recent patent, high boiling fractions or residues from tar distillates incorporated with asphaltic bituminous materials increase their wetting properties (52). Coal tar products are also added to petroleum products to give highly ductile and quick setting cements (54). Asphaltic bitumen is also blended with tar (53), hard asphalt (55), fluxed cracking still residue (56), creosote (58), fuel oils (57), rubber-like pitch (59) and waxes (60) to give desired products.

Blends prepared by mixing emulsions of the different constituents are described in several patents (61, 63, 64, 65, 66, 67). Such mixtures of emulsions may be prevented from coalescence before application by means of a dispersing film (62). Blends effected by mixing one of the constituents with the mineral aggregate and then adding the other constituents are also treated in recent literature (68, 69, 70, 71, 72, 73, 74). In another patent, one of the constituents is mixed with a portion of the aggregate and the other constituent with the remainder of the aggregate and then these two mixtures are combined (75, 76). Porous material such as diatomaceous earth, tripoli, etc., is used to absorb a flux which is later set free by pressure after being mixed with the aggregate and a hard bituminous binder (77). Gum rosin or paraffin may be added to asphalt when mixing it with aggregate in order to reduce the surface tension of the asphalt (78). An aggregate can be mixed with successive portions of a blend of asphalt and a flux, with each added portion having a higher percentage of asphalt (79).

The fact that the constituents of asphalt as designated by Marcusson, e.g., asphaltous acids, asphaltous anhydrates, asphaltenes, asphaltic resins, and oily constituents, are separable by means of solvents is utilized in the preparation of asphalts having specified properties. Thus, asphalts are fractionated by the use of propane and phenol into oils, resins, and asphaltenes, and these fractions united in such a way as to give asphalts having desired physical properties (83). Liquefied hydrocarbons and others of low boiling point and their mixtures are used to dissolve portions of asphaltic bitumen and to give precipitates with varying degrees of hardness (82). Besides lower petroleum fractions, mixtures of cyclic alcohols with ethanol, propanol, and iso-propanol are also used for this purpose (80). An asphaltic bitumen which has been deprived of oil in this way may be mixed with a different oil to give desired properties (81). A low grade asphalt can be improved by the addition of resins from cracked petroleum which have been substantially freed of asphaltenes and oily constituents (84).

## Cutting

"Cut-back asphalts" consist of asphaltic bitumen that has been cut with a distillate fraction to meet certain specifications or to facilitate handling without application of heat. Such mixtures which contains 70-83% asphalt and 30-17% distillate, both produced by cracking petroleum oil, have been patented as rapid setting asphalts (85). Other bituminous substances, as well as residual asphalts, can be mixed with volatile diluents, e.g., benzene (86), mixtures of benzene and naphtha (87) or mixtures of naphtha and kerosene (88). The removal of volatile thinners, after an aggregate has been added, can be accelerated by the application of a vacuum (89) or of a flame (90).

## Emulsions

The increase in the use of emulsions of bituminous materials is manifested by the number of patents which have appeared concerning their preparation and application. A variety of emulsifying agents have been proposed for dispersing bitumen in water, and those which appear in recent patents are listed below:

tri-alkali phosphate (91)
cholesterol (92)
by-products from carbonating saccharine juices (93)
starchy colloid (94, 95)
condensation product of proteins and formaldehyde (96)
albuminoid treated with formaldehyde (97)
gelatin (98)
viscose (99)
substances containing montanic acid (100)
neutralized sludge sulfonic acid (101)
Na or K Salts of petroleum sulfonic acids (102)
$NH_4$ or alkali salts of alkyl sulfuric acid (103)
alkali salt of a sulfonated oil (104)
alkali treated phosphatides (105)
saponified products of materials such as "red oil" (106)
triethanolamine oleate (107)
saponified cotton seed-oil pitch (108)
animal fat acids and potassium hydroxide or carbonate (109)
soap produced *in situ* (110)
NaOH and oleic acid (111)
oleic acid and ammonia (112)
green acid soap (113)
rosin soap with an albuminoid (114)
Na or K rosin soap heat treated at about 260-315° (115)
B rosin soap containing 10-20% of unsaponifiables (116)
salts of Fe, Al, or Cr added to concentrated waste sulfite liquor (117)
pitchy products from the evaporation of sulfite liquor (118)

sulfite cellulose lye (119)
humic acid and similar substances (120) sometimes heated with an alkali solution (140)
bituminous minerals, coals or lignites (121, 122)
soluble soaps and mineral colloids (123)
colloidal clay (124, 125)
tannic acid and finely divided asbestine or gilsonite (126)
alkali metasilicate (127)
colloidal hydrous magnesium silicate (128)
silica or slate dust with tannic acid or soap (129)
water glass and hot milk of lime (130)

In conjunction with emulsifying agents, stabilizers are used to prevent coagulation during storage or low temperatures. Most of these agents act directly as protective colloids; but such substances as soluble salts can also be added which react with substances already present to form products which act as protective colloids. In addition to substances named in the last paragraph and which assist in both dispersion and stabilization, the following substances are mentioned as stabilizers:

water soluble salts as NaCl, $Na_2SO_4$, etc., in small amounts (131, 132)
bivalent or tervalent electrolytes (133)
condensation products of formaldehyde and phenols (134)
bile salts (135)
saponified products of materials adsorbed on spent fuller's earth after use in filtering cracked petroleum vapors (136)
tannic acid with ferrous sulfate (137)
tannic acid (138)
resins such as colophony or coumarone resin (139)
starch (140)
farinaceous protein as corn-gluten meal or soybean meal (141)
gelatin (142, 143)
casein and caseinates (144, 145, 146, 147)

Better emulsification is effected by addition of materials such as 0.5-30.0% of finely divided brown coal, poor in humic acid (148), unsaturated liquid fat acids, resinic acids, or higher cyclic alcohols and subjection to air blowing (149), 5-10% of a natural asphalt of high saponification number (150), and 5% lye added to molten bitumen (151).

Emulsions of bituminous material are, in nearly all cases, made by the use of agitators or colloid mills with emulsification generally accomplished with the water being at some temperature below that of the melting point of the bitumen and with the bitumen either in a solid or liquid condition. A recent patent covers the preparation of emulsions by feeding the bitumen at a temperature less than 100° above its melting point into an emulsification zone maintained at the melting point of the bitumen (163). Unstable emulsions which are applied immediately after preparation are made by atomizing the bitumen with steam under pressure (152), by subjecting a water-bitumen mixture under pressure to baffling (153), or by heating the bitumen above 100° C. and pouring it into water heated to 95-100° C. at such a speed that superheating of the water causes the dispersion of the bitumen (154).

Bituminous emulsions of the oil-in-water type can be inverted by the addition of aluminum sulfate (155). The mobility of stiff emulsions can be increased without the use of a diluent by adding .007% citric acid (156). Alkyl tartrates and aromatic alcohols may be used as plasticizers (157). Decreased viscosity of equal bitumen content may be attained by combining emulsions prepared with different emulsifying agents (158). Addition of asbestos and small amounts of soluble fluoride is used to give emulsions a desired consistency (159).

Emulsification can be effected after the bitumen has been added to the aggregate by mixing the coated aggregate with an emulsifying agent to give partial emulsification largely on the surface of the bitumen coated particles (160). An emulsifying agent such as NaOH added during the mixing of the aggregate and bitumen gives a coated aggregate with a film of water between the coated particles (161).

For some purposes, ready breaking of the emulsion when in contact with the mineral aggregate is desired. To this end, a finely divided oxide of an amphoteric element such as antimony or titanium can be added, which does not substantially flocculate the emulsion, but which does accelerate its coalescence after application on the aggregate (164). Alkali salts of amphoteric oxides such as sodium aluminate, zincate, or plumbate are proposed for the same purpose (165). Instead of adding some material to the emulsion, the aggregate may be treated with substances such as alum solutions to bring about coagulation of the emulsion (166). The breaking of an emulsion after it has been mixed with an aggregate can also be effected by treating the mixture with a destabilizing agent such as a weak acid, an ammonium salt of a weak acid, or an oxide of an amphoteric metal (167).

## Mineral Fillers

The addition of lime with or without other materials to bituminous road materials (170, 171, 172), and more particularly to tars (168, 169), accelerates their hardening. The incorporation of mineral fillers such as calcium carbonate is used to increase the tensile strength, the fusion-point and the hardness, and to lower their susceptibility factor and their ductility. Finely ground limestone is being added singly as the filler in a bituminous road binder for coarse aggregate (173, 174, 175) or in combination with sand (176, 177, 178, 179). The calcium carbonate can be added in the form of the by-product "sugar scum" or sugar "carbonation mud" (180).

Portland cement can be used to improve the properties of bituminous materials in road mixes (190, 191). On the other hand, bitumen is used to improve the water imperviousness and to decrease the shrinkage of portland cement concrete, but it also reduces its tensile and compressive strengths (182, 183). An optimum amount of bitumen of 3-4% gives a better ratio of tensile to compressive strength and causes the cement to become more elastic (184). An addition of less than 7% of bitumen is recommended (185). Polyhydric alcohols can be added to facilitate the mixing of the bitumen with the portland cement (186). The bitumen is sometimes dissolved in a non-aqueous solvent prior to mixing with the concrete (187) or the bitumen is first mixed with a stone aggregate and then with the portland cement to which a water-absorbing material such as wood-meal has been added (188). The addition of bitumen to portland cement concrete appears to be an advantage when surface dressing of bitumen is applied (189).

The admixture of various other inorganic substances to bituminous materials is claimed to improve the properties of road mixes. Such substances are alkali silicates (192), fluosilicates (193), burned gypsum (194), iron oxide (195), spent oxide or cyanide residues (181),

slag (196, 197, 198, 199) and absorbent earths (200, 201, 202). The effect of inorganic substances may be attributed to one or more of several things, namely, catalytic effect on polymerization and condensation, absorption, or direct reaction with constituents of the bitumen. Particles of anhydrous $MgCl_2$ may be incorporated with bituminous materials to absorb water (203, 204).

## Carbonaceous Fillers

Carbonaceous materials such as powdered coal or brown coal (205, 206, 207) or powdered charcoal (208) are proposed as fillers for bituminous substances to increase their weather resistance and hardness. Coarse particles of coke are recommended for incorporation in aggregate-bitumen mixes (209, 210, 211, 212) to aid in mixing, to store the bitumen, to absorb excess binder, and to improve the stability of the mixture.

## Pretreatment of the Aggregate

Before mixing a bituminous binder with an aggregate, the aggregate may be treated with a primer to facilitate the mixing and coating of the aggregate with the binder. Certain types of cut-back asphalts have been used for this purpose. Volatile priming or fluxing oils (213, 214) and oils containing an emulsifying agent are recommended in the literature (215). Other materials used for pretreatment of the aggregate are volatile solvents such as naphtha, kerosene, or gasoline (216, 217, 218, 219, 220) or a volatile solvent containing an emulsifying agent for forming an oil-in-water emulsion with the moisture content of the aggregate (221). The volatile solvent may be absorbed by an absorbent earth and after this is mixed with the aggregate, the volatile liquid is released by application of pressure (222, 223). Bituminous emulsions (225, 226, 227, 228, 229) and also solutions containing azocyclic bases such as pyridine can be used as primers (224). It is proposed to dry the aggregate at a temperature above the boiling point of water preceding the application of a bituminous emulsion (230, 231, 232).

## Mixing and Application

Aside from the individual properties of the bituminous material and of the aggregate, the quality of a particular road mixture depends on the method of mixing, several types of which are described in the recent patent literature. One method consists of heating the aggregate and bitumen separately and mixing and pouring white hot (223, 234). The mass may also be allowed to cool under continued manipulation (235). The cooling under agitation may be accelerated artificially (236). The bitumen may be mixed with the coarse portion of the aggregate with following addition of the fines (239), after which further asphaltic material can be added (240). The bitumen can also be mixed with fines and the coarse material added last (242). Also, the coarse particles and the fines may be mixed separately with bitumen and then both portions mixed together (241). A rather different method consists of diffusing fine mineral matter by an air blast and spraying the melted bitumen across the current of solids (237). An aggregate-bitumen composition may be subjected, during laying, to violent mixing and beating as it is moved by scrapers over the surface of the roadway (238). Mixes prepared some time previous to laying are either made with an excess of aggregate (243) or with an excess of binder (244). Aggregate and binder can be laid in stratified layers (245) or in layers containing graded aggregate and bitumen with the aggregate size decreasing in the successive layers (246). A bitumen-aggregate pavement can be prepared by using a graded aggregate coated with emulsified asphalt possessing a seal coat of stone dust and emulsion on the under side of the pavement (247).

The use of bituminous binders in soil stabilization for the construction of low cost roads has lately been receiving much attention, and several recent patents pertain to methods of mixing soil and bituminous materials. Bitumen with or without admixtures and soil after being heated to assist in mixing can be laid while hot (248) or, after such mixing, powdered and applied by subjecting to heat and pressure (249). Soil can also be mixed with a hard asphalt powder, and a semi-liquid asphalt or a flux added with further addition of soil to give the desired results (250).

## Rock Asphalt

Rock asphalt may be treated in various ways for incorporation in a pavement mixture. Crushed rock asphalt can be softened by using an asphaltic flux (252, 253), or it can be treated with a solvent such as naphtha or gasoline in an amount sufficient to soften the native asphalt and to facilitate fluxing with another asphaltic material (251). A portion of the bitumen in the rock asphalt can be removed and other bituminous material added to give a product of desired character (254, 255). Another method pertains to maltha containing rock sand which is mixed with an aggregate and heated. Just before the maltha in the rock begins to volatilize an asphaltic cement is added (256).

## Road Dressing

The quality of a bituminous road surfacing depends on the method of application and can be improved by the incorporation of various materials with the bitumen. Substances which can be added to improve the surfacing properties of bitumens include synthetic resins (257), natural resins (258), coal-tar pitch (259), crude petroleum deprived of its volatile components (260), latex (260), and distillation products of animal matter (261). The following methods of preparing such bituminous road surfaces have been described, besides those already mentioned in other connections:

A mixture of bitumen and pitch is applied after which the aggregate is added and rolled before the binder has set (262).

The undersurface is sprayed with oil, a coating of hard granular material soaked in oil is added, covered with asphalt powder and rolled (263).

An emulsion of bitumen, a layer of small stone chippings, a hot dressing of bituminous material, and a wearing course of coarser chippings of stone are successively applied and rolled (264).

A layer of mineral matter impregnated with a combustible material such as gasoline and kerosene is applied and ignited to burn the combustible matter and to melt the bituminous binder for incorporation with the mineral matter (265).

The aggregate particles are coated with a bitumen liquid at ordinary temperatures, and an intermediate layer of a stable bituminous cement, and a final coating of a bituminous flux free from light volatile matter (266).

A mineral aggregate of grain sizes for minimum pore space is mixed with a liquid and powdered solid binding agent (267).

An aggregate is added to a bituminous binder to give a coarser textured granular surface with large interstices between the particles (268), to provide a non-skid surface. The addition of synthetic resins, mentioned above, is claimed to serve the same purpose.

Mixing tar with finely ground old or waste rubber and dissolving in the least possible amount of solvent at a high temperature (269).

## Conclusion and Acknowledgment

This compilation has been made under the auspices of the Missouri State Highway Department as an available survey of bituminous practice as covered by the recent patent literature and which will be kept up to date by yearly supplements.

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184. Cements with Addition of Bitumen, W. Dyckerhoff, Tonind. Ztg., 57:637, 1933.
185. H. Plauson (to T. R. C. Corp.), U. S., 2,026,988, Jan. 7, 1936.
186. A. Sommer (to T. R. C. Corp.), U. S., 1,975,485, Oct. 2, 1934.
187. Osterreichisch-Amerikanische Magnesit, A.-G., Austrian, 141,510, April 25, 1935.
188. E. Russwurm, Austrian, 129,775, April 15, 1932.
189. L. G. Gabriel and J. F. Blott (to Colas Roads, Inc.), U. S., 1,953,294, April 3, 1934.
190. "Straba" Strassenbaubedarfs, A.-G., Fr., 794,524, Feb. 19, 1936.
191. J. B. Chapline (one fourth to G. D. Patterson), U. S., 1,979,251, Nov. 6, 1934.
192. Henkel & Cie., G.m.b.H., Ger., 606,655, Dec. 7, 1934.
193. P. R. Smith (to Barber Asphalt Co.), U. S., 2,033,657, Mar. 10, 1936.
194. E. R. Taylor, Ger., 576,768, May 16, 1933.
195. I. G. Farbenindustrie, A.-G., Brit., 433,874, Aug. 22, 1935.
196. A. Esser and B. Fisel, Belg., 408,393, April 30, 1935.
197. L. C. Abraham and Rudolph Schmidtmann, Fr., 732,142, Feb. 20, 1932.
198. Soc. anon. des ciments portland de Rombas, Fr., 784,582, July 22, 1935.
199. A. S. Hirzel, U. S., 1,940,417, Dec. 19, 1933.
200. Soc. anon. des etablissements Jean Francois, Fr., 751,956, Sept. 13, 1933.
201. R. Herrmann, Ltd., and Alan Wolf, Brit., 424,415, Feb. 18, 1935.
202. Berry, Wiggins & Co., Ltd., and H. H. Holmes, Brit., 443,471, Feb. 28, 1936.
203. I. G. Farbenind., A.-G., Fr., 766,194, June 22, 1934.
204. I. G. Farbenindustrie, A.-G., Brit., 433,957, Aug. 23, 1935.
205. Soc. de recherches et de perfectionnements industriels, Brit., 431,474, July 8, 1935.
206. Ges. fur Teerstrassenbau m.b.H., Ger., 631,289, June 17, 1936.
207. Soc. de recherches et de perfectionnements industriels, Brit., 430,061, June 12, 1935.
208. Soc. de recherches et de perfectionnements industriels, Fr., 44,832, April 15, 1935.
209. John Radcliffe, U. S., 2,037,147, April 14, 1936.
210. Hans Wiedemann, Ger., 604,114, July 3, 1936.
211. Hans Wiedemann, Brit., 407,460, March 22, 1934.
212. John Radcliffe, Brit., 387,324, Jan. 26, 1933.
213. Charles A. Mullen, U. S., 1,929,388, Oct. 3, 1933.
214. Robert P. Fletcher, Jr., U. S., 1,940,645, Dec. 19, 1933.
215. K. E. McConnaughay (to Precote Corp.), U. S., 2,003,861, June 4, 1936.
216. L. R. MacKenzie (to L. R. MacKenzie, Inc.), U. S., 1,955,077, April 17, 1934.
217. Geo. W. Alsdorf, U. S., 1,842,139, Jan. 19, 1932.
218. D. M. Hepburn (to Amiesite Asphalt Co. of America), U. S., 1,827,522, Oct. 13, 1931.
219. A. S. Hirzel, U. S., 1,975,458, Oct. 2, 1934.
220. Wm. L. Schloss, U. S., 2,051,577, Aug. 18, 1936.
221. S. S. Sadtler and E. F. Cayo (to Amiesite Asphalt Co. of America), U. S., 1,834,552, Dec. 1, 1931.
222. S. S. Sadtler (to Amiesite Asphalt Co. of America), U. S., 1,824,931, Sept. 29, 1931.
223. A. B. C. Dahlberg, Swed., 76,684, March 7, 1933.
224. G. Rodewald (to Amber Size and Chem. Co., Ltd.), U. S., 1,854,348, April 19, 1932.
225. Jan van Hulst (to Patent and Licensing Corp.), U. S., 2,051,505, Aug. 18, 1936.
226. D. W. Johnston (to Flintkote Co.), U. S., 1,985,572, Dec. 25, 1934.
227. G. H. Alvey (to Uvalde Rock Asphalt Co.), U. S., 1,928,303, Sept. 26, 1933.
228. A. F. Malchow, A.-G., Ger., 575,105, April 24, 1933.
229. C. N. Forrest (to Barber Asphalt Co.), U. S., 2,025,945, Dec. 31, 1935.
230. V. E. Watts (to International Bitumen Emulsions Corp.), Can., 356,608, March 17, 1936.
231. C. F. Carroll (to American Bitumuls Co.), U. S., 2,012,496, Aug. 27, 1935.
232. V. E. Watts (to American Bitumuls Co.), U. S., 2,016,306, Oct. 8, 1935.
233. O. M. Paddleford, U. S., 1,789,447, Jan. 20, 1931.
234. The Midland Tar Distillers, Ltd., T. E. Fellows and Wm. Gooch, Brit., 381,298, Oct. 6, 1932.
235. G. G. Heghinian, U. S., 2,009,886, July 30, 1935.
236. C. R. Arnold, U. S., 1,859,324, May 24, 1932.
237. A. D. Brito, U. S., 1,854,100, April 12, 1932.
238. E. B. Cadwell and A. B. Webb (to Edwin B. Cadwell), U. S., 2,015,707, Oct. 1, 1935.
239. Wm. F. Rees and Wm. F. Rees, Ltd., Brit., 430,979, June 28, 1935.
240. R. M. Grower (to Samuel J. Tomaselo), U. S., 2,040,481, May 12, 1936.
241. G. D. Coletta, Ger., 586,423, Oct. 21, 1933.
242. "Straba" Strassenbaubedarfs, A.-G., Fr., 797,717, May 2, 1936.
243. Robert Illemann, Brit., 439,272, Dec. 3, 1935.
244. John Radcliffe, Brit., 388,731, Feb. 27, 1933.
245. E. F. Durfee (to Koppers Products Co.), U. S., 2,043,037, June 2, 1936.
246. H. Fritsch (to Fox, Stockwell & Co.), U. S., 1,834,835, Dec. 1, 1931.
247. C. L. McKesson (to American Bitumuls Co.), U. S., 1,884,795, Oct. 25, 1932.
248. Wm. J. Woodfine, Brit., 441,503, Jan. 21, 1936.
249. Wm. Griffiths, Brit., 376,792, July 13, 1932.
250. Wm. C. West (to West Process Pavement Co.), U. S., 1,812.730, June 30, 1931.
251. J. H. Conzelman (to Alabama Asphaltic Limestone Co.), U. S., 2,026,614, Jan. 7, 1936.
252. R. L. White, U. S., 1,818,876, Aug. 11, 1931.
253. G. H. Alvey (to Uvalde Rock Asphalt Co.), U. S., 1,946,517, Feb. 13, 1934.
254. G. H. Alvey (to Uvalde Rock Asphalt Co.), U. S., 1,906,301, May 2, 1933.
255. H. C. Wolf (to Wolf Engineering Co.), U. S., 2,032,680, March 3, 1936.
256. James W. Fraser, U. S., 2,036,130, March 31, 1936.
257. Alexander Supan, Ger., 574,527, April 13, 1933.
258. Bruno Peckie, Ger., 597,708, May 30, 1934.
259. E. O. Rhodes (to American Tar Products Co.), U. S., 2,039,450, May 5, 1936.
260. J. W. Clark (to Neuberger Chemical Corp.), U. S., 1,875,802, Sept. 6, 1932.
261. Amber Size & Chemical Co., Ltd., Ger., 572,640, March 20, 1933.
262. Frederick Morton, Brit., 412,404, June 28, 1934.
263. E. R. Zetter, Swiss, 180,616, Jan. 16, 1936.
264. F. Wm. Valle-Jones, Brit., 425,148, March 7, 1935.
265. Carl W. Allshouse, U. S., 1,958,506, May 15, 1934.
266. Sam E. Finley, U. S., 1,991,319, Feb. 12, 1935.
267. J. Löwinger, Brit., 442,508, Feb. 5, 1936.
268. E. C. Wallace, U. S., 1,975,028, Sept. 25, 1934.
269. Alphons Wyss, Swiss, 180,967, Feb. 17, 1936.

# REGULATIONS FOR SECONDARY HIGHWAY IMPROVEMENTS

Rules and regulations for the improvement of secondary or feeder roads under the expenditure of $25,000,000 Federal Aid apportioned last December to the various states were approved by the Secretary of Agriculture on Feb. 12. The Federal funds are to be administered by the U. S. Bureau of Public Roads in cooperation with the state highway departments. The Federal funds must be matched by equal amounts of state funds, and are for expenditure on secondary highway construction projects initiated by the various state highway departments and approved by the U. S. Secretary of Agriculture. The funds become available July 1 for payments to the states for completed work and remain available for two years. The apportionment to the states was given in the January issue of ROADS AND STREETS. The new apportionments of funds for this purpose are the first to be made as a part of the regular Federal program.

The new rules and regulations give the following definitions:

"'Secondary or Feeder Roads' shall mean roads outside of municipalities, except as hereafter provided, which are not included in the Federal Aid highway system, and shall include farm-to-market roads, mine-to-market roads, rural free delivery mail roads, public school bus routes and other rural roads of community value which connect with important highways or which extend reasonably adequate highway service from such highways, or which lead to rail or water shipping points or local settlements. The limitation with respect to roads within municipalities shall not be construed to prevent improvements into or through small municipalities when such improvements are necessary for continuity of service."

"'Municipality' shall mean a populous community, generally of defined area, usually organized pursuant to law into a body politic with corporate name and continuous succession and for the purpose and with the authority of subordinate local self-government."

Further extracts from the rules and regulations follow:

*Initiation of Projects*—All projects under this act shall be initiated by the states and submitted in the same manner as other Federal-aid projects, and all such projects shall be subject to all of the provisions of the rules and regulations of the Secretary of Agriculture in effect for administering the Federal Highway Act, as amended, except such provisions as are inconsistent or in conflict with these rules and regulations.

*Application of Funds to Projects*—The funds apportioned to any state under the act shall be applied to projects, essentially rural in character, that are not on highway routes which are potential additions to the Federal-aid highway system within a reasonable interval.

In states where the mileage of the state highway system is a small percentage of the total highway mileage of the state, the chief of the Bureau of Public Roads shall determine to what extent secondary or feeder road projects may be located on the state highway system.

To accomplish a wide distribution of benefits within each state in the expenditure of funds authoried by the act without a sacrifice of administrative or construction efficiency, the chief of the Bureau of Public Roads shall determine the minimum percentage of counties, applicable alike in each state, in which the funds authoried for any one or more fiscal years shall be used: Provided, That the cost chargeable to secondary highway funds of projects programmed for construction in a state in any one fiscal year shall not exceed the amount of such funds available to the state.

No projects shall be undertaken which do not provide for a surfacing or stabilization of the roadbed which shall be reasonably satisfactory for the traffic served. Grading and drainage as first stage construction may be accepted: Provided, The state highway department will enter into a satisfactory agreement for future surfacing or stabilization of the roadbed.

*Selection of Projects*—Each state highway department shall undertake the selection and designation of an initial system or group of secondary or feeder roads for construction or reconstruction based upon their relative importance as determined from factual data secured from state-wide studies for the planning of a complete highway system, and submit a suitable description and map of such proposed system or group to the Bureau of Public Roads for approval: Provided, That prior to the selection, designation and approval of such system or group of secondary or feeder roads, projects may be approved for construction if it is reasonably anticipated that such projects will become a part of such system or group.

The mileage of the initial system or group of secondary or feeder roads in any state shall not exceed ten per cent of the highway mileage of the state as shown by the records of the state highway department at the time of the passage of the Federal Highway Act. The initial system or group of secondary or feeder roads may be selected, designated and approved in whole or in part in any state and may be modified, or increased from time to time as justified by the progress of its improvement.

After a secondary or feeder system or group of highways has been selected, designated and approved in any state no project shall be approved which is not a part of a route embraced in such system or group.

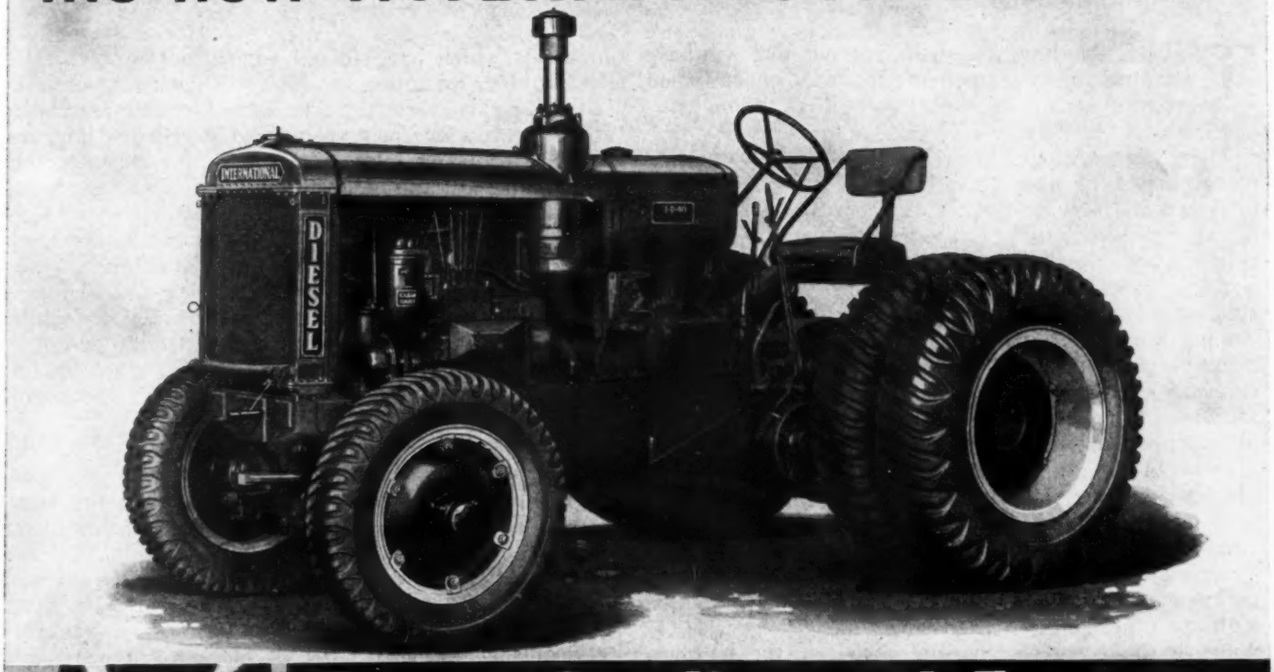
*Surveys, Plans, Specifications, Etc.*—Surveys and plans, specifications and estimates for all projects in each state shall correspond to the character of the work contemplated and shall be in sufficient detail to show the quantity and kind of work involved and shall be prepared under the immediate direction of the state highway department without reimbursement from Federal funds. The state highway department, however, may utilize the services of well qualified county engineering organizations, acting under its direction, for the surveys, preparation of plans, specifications and estimates, and for the supervision of construction for any project. Inasmuch as the Federal Highway Act requires each state to maintain at its own expense a state highway department having adequate powers and suitably equipped and organized to discharge the duties required by the legislation, no part of the cost of maintaining a central office organization of the state highway department or of any organization which may be utilized by the state for construction engineering and inspection shall be paid with Federal funds. Construction engineering and inspection charges reimbursable with Federal funds shall be limited to any necessary costs incurred and to the salaries of individuals directly employed on the project.

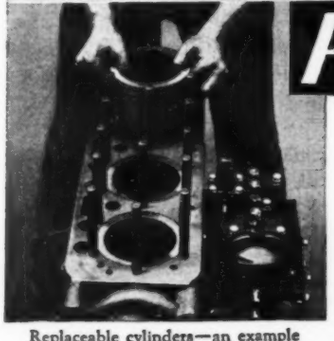
*Methods of Undertaking Work*—Whenever feasible and practicable the contract method shall be followed in performing work.

*Highway Planning Projects*—With the approval of the secretary, not to exceed one and one-half per centum of the amount apportioned to any state for secondary or feeder roads may be used for surveys, plans, engineering and economic investigations of projects for future construction in such state, or for the planning of a complete highway system and future programs of highway improvement for such state. Such proposed surveys, plans and engineering investigations shall be initiated by the state highway department in the same manner as are other projects by the submission of a project statement and, if approved by the secretary, the work may be prosecuted under a project agreement.

*Maintenance*—Project agreements for secondary or feeder road projects shall provide for the maintenance of such projects by the state to the extent permitted by state law; otherwise, the state shall submit, in the form prescribed by the secretary, an agreement for such maintenance with the county or other political subdivisions responsible therefor: Provided, however, no project contemplating maintenance by a county or other political subdivision shall be approved if any road previously improved with Federal funds under the provisions of the Federal Highway Act, as amended and supplemented, which the said county or other political subdivision has agreed to maintain, is not being satisfactorily maintained as determined by the chief of the Bureau of Public Roads.

# America's FIRST Diesel-Powered Industrial Wheel Tractor . . . the new INTERNATIONAL ID-40



Replaceable cylinders—an example of the big money-saving features built into all International Tractors.


The Model ID-40 is as easy to crank as a gasoline tractor of corresponding size.

## Power, Quality and Economy

● International Harvester, world's largest tractor builder, scores another *first* with the new Model ID-40. This organization has adapted the Diesel principle to wheel-type industrial tractor operation, the first time this has been done in America. This new tractor uses the same International Diesel engine that has proved so successful in the International TD-40 TracTracTor and the Model PD-40 Power Unit. The Model ID-40 Tractor has power and stamina to handle a variety of heavy-duty work calling for a wheel tractor. Investigate this new addition to the line of International Industrial Power, which includes wheel and crawler tractors, and power units from 12 to more than 100 h. p.

**INTERNATIONAL HARVESTER COMPANY**
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**INTERNATIONAL Model I-40**
This tractor is also new in the International Industrial Power line. It is similar in design and construction to the Model ID-40 but is powered with the efficient 6-cylinder gasoline engine used in the Model T-40 TracTracTor. Both of these tractors have the well-known features of International manufacture which mean so much to the user in low operating costs and maintenance economy.

## INTERNATIONAL HARVESTER

# HIGHWAY ADMINISTRATION AND CONSTRUCTION PROBLEMS

By THOS. H. MacDONALD
*Chief, U. S. Bureau of Public Roads*
*Washington, D. C.*

THERE are three well-defined trends that will have a major influence upon the highway improvement program and, thus, importantly affect the highway construction industry.

These are: Changes in design standards for the primary purpose of meeting safety requirements; changes in design and specifications and in construction methods to make full utilization of the new technical knowledge that has been developed to the point of general application; and the application on a constantly increasing scale of advanced planning of the highway system, including the orderly budgeting of the highway improvement program on the basis of known necessities and carefully determined priorities. The third trend will be affected, at least for some time to come, by the objective of providing opportunity for employment.

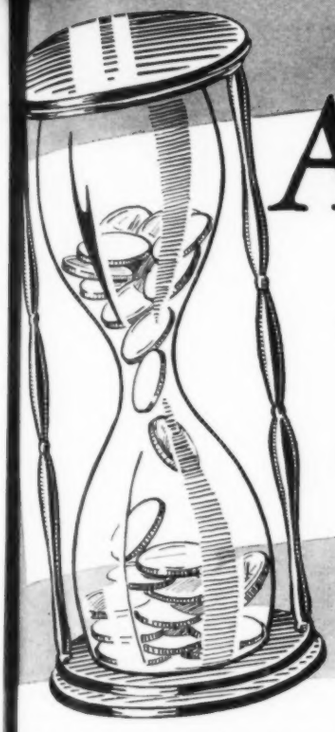
None of these trends is new. Each one in some degree is now in operation. The difference will lie in the preponderant influence which they will exert upon the future policies and annual undertakings and in their general application by all of the states. These are the outgrowth of the response of the state and federal highway officials, and other governmental agencies, to improve the economy and the scope of the highway service, and reflect the increasing maturity of the approach to the highway problem.

Sound principles of engineering and administration developed from adequate data and records of experience are being rapidly built under the highway administrative structure, displacing lack of knowledge and indefinite objectives.

These developments will further accent the changing problems which have forced contractors to revise and revamp their organizations during the past several years. This thought is brought frankly before this association for the purpose of being helpful in the further improvement of working relations between the contractors of the country and the highway officials. There are a considerable number of lingering sighs for a return to the time when the contractors' operations were not so closely determined by rules and regulations. That time is pretty definitely past. But this does not mean that there will be any lack of sympathetic consideration of well-founded criticism, or any failure constantly to improve all requirements that do not make for higher class production with economy, or better conditions for contractors and the labor they employ.

*The Selection of Skilled Labor.*—In support of this assurance it may be of interest to review briefly some of the experiences of the past years when the emergency programs have been in operation. Probably contractors and highway officials would agree that the major difficulty with the rules and regulations which were first placed in effect by the Bureau of Public Roads grew out of the requirement relating to the selection of skilled labor. These criticisms had proven merit, and were met by the elimination of the requirement, and definitely placing the contractor in the position of the sole judge of the employability of the skilled worker. However, there is the thought that the regulation failed more because of a lack of a sufficient number of workmen highly skilled in the various positions on the typical contractor's organization—a condition which seems to be growing in seriousness—than to any lack of ef-

*Pedestrian Bridge from Tamm Avenue to Forest Park Across the Express Highway, St. Louis, Missouri.*
*Photo by Courtesy of Missouri State Highway Department*



# A BRICK SURFACE WILL PAY FOR ITSELF OUT OF SAVINGS IN A *Short Time*

"Good roads pay for themselves" was the battle cry under which the nation lifted itself out of the mud a decade and a half ago. It has proven itself to be true.

The excessive costs of gas, tires and lost time of the "mud era" have been largely corrected. But there is still room for important savings by lessening the present day cost of pavement up keep and replacement.

## Resists Weather Damage

The *rate* at which a well-traveled highway pays for itself increases as upkeep is lessened. The total profit of the highway is increased by giving it longer life.

A brick pavement is generally conceded to have the longest life and the lowest upkeep. Common observation: many a veteran brick street rides as well and looks better than other types from 20 to 30 years younger. The reason is because weather cannot start damage which traffic hammers into final destruction.

## Unequalled For Riding Comfort

Modern manufacture of brick and modern engineering and construction methods give unequalled riding comfort and safety.

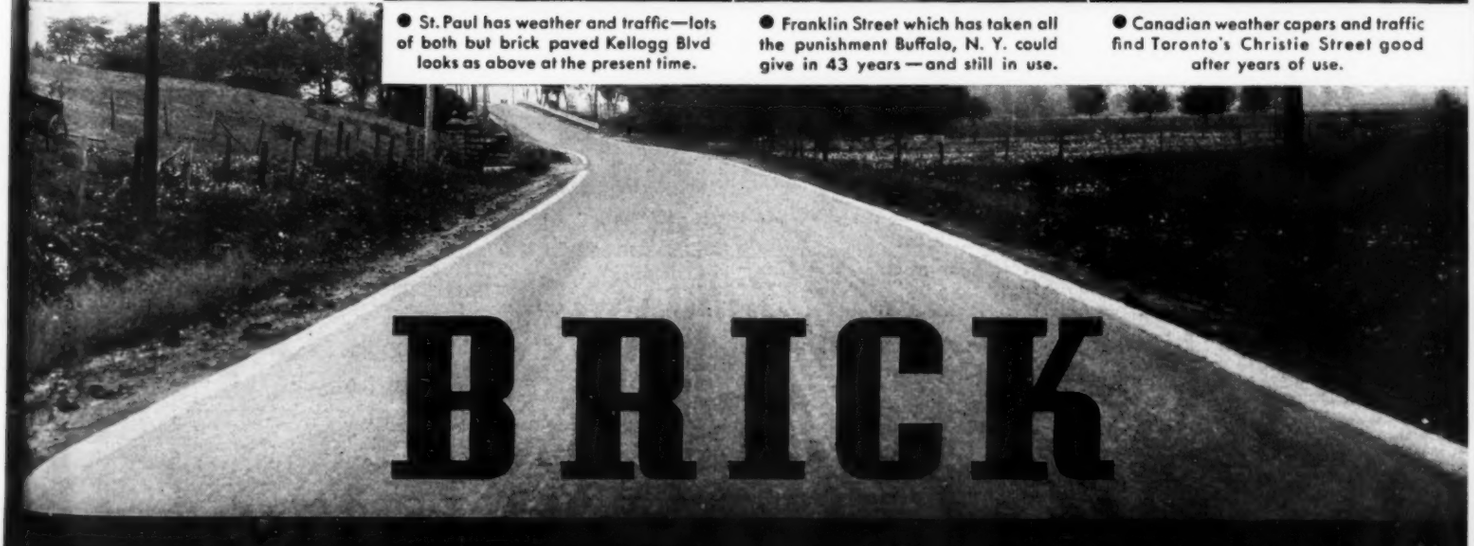
Build new jobs with a brick surface. Resurface failing slabs with brick—it's better and cheaper. National Paving Brick Association, (Affiliated with Structural Clay Products, Inc.) National Press Building, Washington, D. C.

Exhibitor A. R. B. A. Convention, New Orleans, January 11-16, 1937
31st Annual Meeting National Paving Brick Association, Detroit, January 27-29, 1937

● St. Paul has weather and traffic—lots of both but brick paved Kellogg Blvd looks as above at the present time.

● Franklin Street which has taken all the punishment Buffalo, N. Y. could give in 43 years—and still in use.

● Canadian weather capers and traffic find Toronto's Christie Street good after years of use.



# BRICK

FOR NEW CONSTRUCTION OR RESURFACE JOBS

fort on the part of the public employment services or cooperation on the part of the contractors.

The absorption of the available workmen in the skilled and intermediate grades has now justified releasing the choice of these wholly to the contractor, retaining for him, however, the services of the public employment agencies here sought. The regulations for the new programs retain the selection of unskilled labor through the employment agencies, but they do so to meet a definite need on the part of the contractors. To assist in handling the new problems of unemployment insurance and stabilization of employment, a plan is being worked out that will permit an individual of unskilled grade who has been employed by a contractor, after referral by an employment agency, to continue in the employ of the contractor until released by him. It will be noted that this improves the workman's status and at the same time assists the contractor by applying employment to a continuing organization rather than to the individual projects.

*Classification of Labor on Works Program Projects.*—An analysis of 2,961 Works Program highway and grade crossing projects shows that the four classifications of labor required in each organization are divided among the groups as follows:

| | Per Cent |
|---|---|
| 1. Executive, Administrative and Supervisory | 8.5 |
| a. Superintendents | 1.5 |
| b. Foremen | 5.0 |
| c. Clerical | 2.0 |
| 2. Skilled | 7.8 |
| 3. Intermediate | 15.1 |
| 4. Unskilled | 68.6 |
| | 100.0 |

From this it will be noted that only 7.8 per cent of skilled workmen are required on the average to man organizations that will employ 15.1 per cent of intermediate and 68.6 per cent of unskilled grade workmen. Because of the indications that even this small percentage of highly skilled individuals is becoming difficult to secure, it is hoped that the change in administrative procedure here indicated will assist contractors to overcome any lack of skilled workmen by permitting them to retain and develop workmen of promise from the unskilled grades. The requirement for the fixing of minimum wages by the state highway department has, on the whole, worked well, although there have been cases of complaint, some of which are justified. The classification of positions has been criticized by labor unions in organized areas, but these criticisms have revolved around only a few positions. The new regulations have endeavored to reach the cause of these complaints by changing the classifications. These changes have been made upon the basis of the increased quality of the product which should be secured by workmen skilled in the operation. While the principle carried by the former regulations as the basis for the classifications has permitted the contracting agencies to make changes where justified by the degree of skill demanded, this principle was not uniformly applied, and the criticisms have been met by a definite change in classifications.

*Establishment of Minimum Wages.*—It is the judgment of the bureau, after a careful study of the principle of establishment of minimum wages, that this practice is a protection both to the contractor and to the workman. The contractor is protected, particularly during a period of stress such as we have been passing through, in the fixing of the basis for composition. There can be no question that the contracting guild generally desires to treat workmen fairly and to pay as high a level of wages as is consistent with a reasonable cost of production; and the minimum wage requirements relieve those who would deal thus fairly with their workers of the unfair competition of a conscienceless minority who, by heartless exploitation of labor, would attempt to obtain an improper advantage. The protection to the workman is self-evident.

It has been stated frequently in criticism of the fixing of minimum wages that the minimum becomes the maximum. If any authoritative refutation of this charge has been made, it has escaped our notice; so that the data now available from our highway contracts are of timely and important interest.

*Established Wage Rates and Average Wages Paid.*—Minimum wages fixed by administrative action do not become the maximum wages. Table I shows the established wage rates on the Works Program Highway and Grade Crossing Elimination projects, and the average rates actually paid to the first of January of this year. The statement is broken down by states, and the three classes—skilled, intermediate and unskilled labor. Al-

TABLE I—ESTABLISHED WAGE RATE ON WORKS PROGRAM HIGHWAY AND GRADE-CROSSING ELIMINATION PROJECTS AND AVERAGE WAGE RATES REPORTED PAID TO JAN. 1, 1937

| | Skilled Labor | | Intermediate Grade | | Unskilled Labor | |
|---|---|---|---|---|---|---|
| State | Established | Paid | Established | Paid | Established | Paid |
| Ala. | $0.55-$0.85 | $0.84 | $0.35-$0.40 | $0.41 | $0.20-$0.25 | $0.24 |
| Ariz. | 1.00 | 1.06 | .62½ | .72 | .50 | .52 |
| Ark. | .50 | .54 | .35-.37 | .38 | .20-.26 | .21 |
| Calif. | 1.00 | 1.11 | .68 | .77 | .60 | .61 |
| Colo. | .90-1.10 | 1.04 | .60-.70 | .64 | .50-.55 | .51 |
| Conn. | .75-1.20 | 1.06 | .60-.75 | .64 | .50 | .50 |
| Del. | .70-.80 | .80 | .40-.50 | .47 | .25-.35 | .31 |
| Fla. | .55-.70 | .71 | .35-.40 | .41 | .20-.25 | .22 |
| Ga. | .50-.55 | .66 | .30-.35 | .37 | .20-.25 | .22 |
| Idaho | .75 | .89 | .60 | .61 | .50 | .50 |
| Ill. | .75 | 1.08 | .60 | .73 | .50 | .56 |
| Ind. | .49-.66 | .79 | .39-.50 | .50 | .35-.42½ | .42 |
| Ia. | .60 | .73 | .50 | .56 | .40 | .49 |
| Kas. | .60-1.10 | .83 | .40-.70 | .47 | .30-.50 | .34 |
| Ky. | .75-.85 | .91 | .45-.55 | .49 | .30-.37½ | .32 |
| La. | .75 | .80 | .45 | .47 | .30 | .30 |
| Me. | .80 | .84 | .50 | .51 | .40 | .40 |
| Md. | .41-.56 | .72 | .35-.45 | .49 | .27-.35 | .34 |
| Mass. | 1.20 | 1.26 | .75 | .81 | .50 | .56 |
| Mich. | .45-.76 | .77 | .37-.58 | .50 | .32-.50 | .39 |
| Minn. | .90-1.20 | 1.05 | .65-1.00 | .65 | .50-.62 | .52 |
| Miss. | .65 | .77 | .35 | .39 | .22½ | .23 |
| Mo. | .60-1.25 | .86 | .40-.65 | .50 | .30-.45 | .36 |
| Mont. | 1.00 | 1.10 | .75 | .82 | .60 | .62 |
| Neb. | .50-.60 | .64 | .40-.50 | .46 | .30-.40 | .33 |
| Nev. | .90 | 1.00 | .70 | .72 | .62½ | .63 |
| N. H. | .75 | .85 | .50 | .54 | .40 | .41 |
| N. J. | 1.20 | 1.28 | .65 | .71 | .40-.50 | .52 |
| N. Mex. | .90 | .99 | .60 | .62 | .40 | .40 |
| N. Y. | .75-.80 | 1.21 | .55-.65 | .71 | .45-.55 | .52 |
| N. C. | .55 | .66 | .35 | .40 | .25 | .25 |
| N. D. | .65 | .73 | .50 | .54 | .40 | .40 |
| Ohio | .65-1.25 | .95 | .50-1.00 | .69 | .45-.65 | .55 |
| Okla. | .75 | .77 | .50 | .50 | .30 | .30 |
| Ore. | 1.20 | 1.22 | .75 | .78 | .50 | .50 |
| Pa. | .55-.75 | .72 | .45-.60 | .50 | .35-.50 | .40 |
| R. I. | .75 | 1.05 | .60 | .64 | .50 | .51 |
| S. C. | .55 | .64 | .35 | .39 | .25 | .25 |
| S. Dak. | .60-.70 | .67 | .45-.50 | .48 | .35-.40 | .35 |
| Tenn. | .75 | .82 | .45 | .47 | .30 | .30 |
| Tex. | .75 | .87 | .45 | .49 | .30 | .31 |
| Utah | .75-.85 | .94 | .60-.65 | .64 | .50-.55 | .51 |
| Vt. | .60 | .71 | .40 | .46 | .35 | .35 |
| Va. | .60 | .71 | .35 | .38 | .25 | .25 |
| Wash. | 1.20 | 1.24 | .75 | .78 | .50 | .53 |
| W. Va. | 1.00-1.10 | 1.04 | .45-.50 | .48 | .40-.45 | .40 |
| Wis. | .60-.90 | .81 | .50-.70 | .57 | .40-.60 | .47 |
| Wyo. | .80 | .93 | .65 | .67 | .55 | .55 |
| D. of C. | 1.00-1.75 | 1.06 | .60-.75 | .62 | .40-.45 | .42 |
| Hawaii | 1.00 | 1.03 | .70 | .71 | .45 | .47 |

most without exception the rates paid in all three grades average considerably above the minimum established wage. In some states the variation is considerably higher than in others. In many of the states there is a range of minimum rates for each grade fixed by the highway department, and in a very large number of the states the average actually paid in the grade is above the maximum fixed for the grade. For example, in New York State in the skilled labor grade the established rates ranged from 75 to 80 ct. per hour. The average paid was $1.21. In the intermediate grade the range was from 55 to 65 ct. per hour—the actual rate paid, 71 ct. In the unskilled labor the range was from 45 to 55 ct. per hour, and the average rate actually paid 52 ct. The range of wage in all classifications is so generally above the established rates as to fix the principle that contractors must, in making their estimates, figure on paying a higher rate of wage than the established rate. This table, it is believed, will be helpful since there is a considerable range in the degree to which this principle is applicable between the different states.

*The Certified Pay Roll.*—There are objections, of course, on the part of some of the contractors, at least, to the certification of pay rolls. The assertion has already been made that the fixing of minimum rates by the administrative agencies protects both the contractor and the workman. The retention of this policy necessarily carries the requirement for the continued submission of the certified pay roll. There will doubtless be agreement that the enforcement of the policy of minimum wages is dependent upon pay roll certification. This appears to the bureau to be substantial support for the requirement, but debate would be fruitless, since it is a matter of Federal legislation applicable to all contracts of every nature involving the expenditure of federal funds.

While there are other changes in the regulations, these comments cover those features concerning which there has been the principal comment and with which, doubtless, the contractors have had the most difficulty. It is believed that the changes in the regulations themselves and in administrative procedure will largely meet merited criticism whether from contractors or from labor.

*An $800,000,000 Program Possible.*—A very large program of highway construction with federal funds and with a combination of federal and state funds is possible for the ensuing year. The construction program for the 3½ year period, July, 1933, to January, 1937, measured by the projects approved annually, totaled $375,000,000, divided between federal funds $315,000,000 and state funds $60,000,000. The Hayden-Cartwright Act provides federal funds that will permit a new program for the ensuing year of $350,000,000, divided between federal funds $200,000,000 and state funds $150,000,000. This new program, together with the balances of previous funds, will make possible a total program of new projects of $560,000,000, of which the states must provide $230,000,000. In addition, the work on going contracts yet to be done would make a total highway and grade crossing elimination program for the ensuing year reaching $800,000,000. There is, however, an "if." It is "if" the states will supply the necessary state funds in the amount required by the terms of cooperation. The amount of state funds required to complete going contracts, together with the amount necessary to meet the allotments for this year for federal-aid and secondary roads approximate $294,000,000.

*Congress Street Excavation, Milwaukee, Wisconsin, July 24, 1936. This Work Involves a Combined Park,-Street and Drainage Project. The Excavation Will Be Spanned by Arch Bridges.*
*Photo by Field Editor*

*States Are Able to Meet Federal Allotments.*—From time to time various rumors gain considerable circulation that the states are not in financial position to supply the funds necessary to meet the federal contributions. A statement of the facts is the best answer to rumors of this character. The real truth is that any states not in a financial position to meet the federal allotments, with only one exception, are deliberately determined to use available funds for other purposes. Even this condition is an exception, applyng to not more than three or four states. Even these latter states, which are slow in taking up their federal-aid funds, or only meeting their allotments in part, are using through other agencies than the state highway departments for road purposes more than the amount required to meet the federal funds. There is no validity to any rumor that the states, with the single exception noted, are unable to meet substantially their federal allotments if they so choose. The proof of this statement is found in the fact that of the 1936 apportionment of $125,000,000, on January first all but $13,000,000 had been definitely ob-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ligated, and half of this amount was credited to four states.

*The Grade Crossing Elimination Program.*—A new departure from the long established principles of the regular federal-aid highway policies, as distinguished from those put into effect as emergency employment measures, is found in the inclusion of the grade cross elimination program, the construction costs to be borne from federal funds without the requirement of being matched by state funds. This policy is designed both to increase the economic utilization and decrease the hazards to the public, and to assist the railroads and the states in providing long needed improvements.

State legislation governing the division of costs for highway-railway crossing improvements between the various units of government and the railroads, now represents an accumulation over a long period. Practically all of the laws contain outgrown requirements in view of the absolutely changed conditions which were definitely recognized in a recent pronouncement by the United States Supreme Court. While in time an equitable division of costs may be worked out, the financial policy now adopted is the only one that will permit effective present action. The fact that the construction costs are being met from the federal funds does not mean that either the states or the railroads are escaping a substantial share of the cost, since all property costs and damage are paid from other than federal funds.

There are many desirable adjustments yet to be made in the grade crossing program. For example, the increased taxation upon the railroads growing out of capital improvements in some instances becomes a real and probably unfair burden, since the benefit largely accrues to the public.

There is also the question of land acquisition. In many of the states the laws for the acquisition of necessary lands for highway, and particularly grade crossing projects, are archaic, unworkable and unduly open to unfair settlement. Some method must be found to secure more promptly the land needed for necessary improvements. If a plan to secure lands with reasonable expedition were generally available, it would have the effect of speeding up the highway and grade crossing improvement program more than any other factor and would incidentally release contractors from many expensive delays and other financial embarrassments.

*Secondary and Feeder Road Construction.*—Provision is also made by the Hayden-Cartwright Act for the construction of secondary and feeder roads with joint federal and state funds shared in the familiar manner of the federal-aid plan. The regulations will require that the work shall be done under the direction of the state highway departments, although the services of qualified county engineering organizations may be used for immediate supervisory purposes. The contract method will be required whenever possible and practicable. State highway departments will be called upon to designate systems or groups of secondary roads on the basis of relative importance as revealed by state-wide studies, to consist initially of not more than 10 per cent of the total highway mileage of the state. The attitude toward this new class of work can be summarized by the statement that the work will be carried out under policies closely approximating those that have obtained in the work on the federal-aid system.

*The Building of Road Grades.*—Brief reference has already been made to the necessity for changed designs and changed construction methods to provide safer and more durable highways. While there are involved many different considerations, one is of particular importance. That is, the application of known knowledge in the building of road grades. The advances which have been made in the technical knowledge of soils and their characteristics and behavior are of major importance. There is already fear that this knowledge may be applied superficially and wholly inadequately. Soil stabilization must be applied to the whole of the road grade including the natural ground on which the grade is superimposed. In bridges we have long considered the most important part of the structure to be that which is not seen and our conception of structural integrity begins with the foundation stratum which is carrying the load. In the building of road grades this same conception must be applied in a degree which has never been approached if we are to have fundamentally sound subgrade structures. Stabilization of soils must be applied not only to a few inches of the surface of the subgrade, but the conception of stability must be extended to the earth stratum which can be relied upon to sustain the load indefinitely. The implications of changes in construction methods involved in this conception are apparent.

While this paper has dealt in a number of details, the purpose has been to disclose through this discussion an underlying approach to problems of highway administration and construction that will fairly correlate and harmonize the interests of the public and the construction industry which must be relied upon to produce these facilities for the public.

As a general commentary upon not only the past year, but upon the several years when public officials and contractors have worked under unusual difficulties and have attempted to meet highly serious problems, the construction industry has made a wonderful record for cooperation and for a generous submerging of personal benefits as a contribution to the public welfare. As a public official who has been in close contact with the highway work, it is a pleasure to make this acknowledgment as a deserved tribute to the construction industry. The foregoing is a paper presented Feb. 15 at the 18th Annual Convention of the Associated General Contractors of America.

▼

## Seek Model Accident Reporting in Study by Highway Patrol

Causes of highway accidents are to be investigated by a specially trained patrol force that will operate on Michigan highways, the Bureau of Public Roads of the U. S. Department of Agriculture announces. A model system for reporting accidents and analyzing the data for accident prevention purposes is to be put into effect as a cooperative undertaking of the Michigan State Police, the International Association of Police Chiefs, the Bureau of Public Roads, the Highway Research Board of the National Research Council, the Michigan State Highway Department, and other agencies.

An accident prevention bureau is to be established at State Police Headquarters at East Lansing, Mich. The police training program, the keeping of records and analysis of data, will be directed by specialists in these lines. The purpose is not only to obtain reliable information as to the causes of accidents but also to develop a model system for collecting this information, so that the improved method may be used generally.

Cooperation by the Bureau of Public Roads is part of a more general program being carried on with the assistance of the Highway Research Board of the National Research Council.

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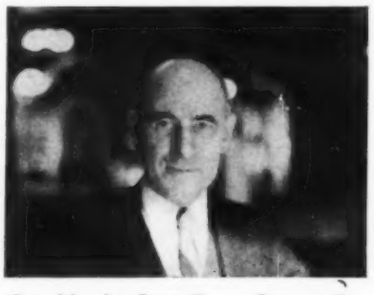

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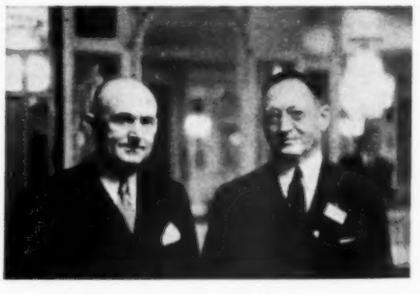

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# METHODS AND COSTS OF ROAD STABILIZATION IN MINNESOTA

By L. L. ALLEN

*Assistant Maintenance Engineer, Minnesota Highway Department*

IT is not the purpose of this paper to compare the economics of high type roads with the more humble stabilized type. Surely the construction of many miles of higher type surfaces has been justified by the gratifying results obtained not alone in Minnesota, but in every other state. Let it suffice to say then that the stabilized road represents a type intermediate between the earth or gravel surface and the higher type of pavements.

As an indication of progress in road stabilization it is interesting to note that a survey by the Committee of Materials of the American Association of State Highway Officials in 1932, disclosed that 13 states and the District of Columbia were equipped with laboratories capable of performing routine soil classification tests which are essential in the design and control of stabilized mixtures. Two years later a compilation by the same committee showed that 27 state highway departments were equipped for soil testing. In addition to the activities of state highway departments, many counties are making soil tests and several commercial companies also provide such service.

## Classification of Stabilized Road Types

Stabilized road types may be divided into several general classes:

1. Natural soil mixtures into which are incorporated commercial products such as crushed stone, gravel and slag.

2. Treatment with substances involving chemical reactions productive of permanent crystallization such as portland cement, calcium silicate and calcium carbonate.

3. Treatment with bituminous materials including oils, tars, cutback asphalts and emulsions as admixtures, or for special treatment to destroy the colloidal properties of soils productive of detrimental volume change.

4. Treatment with sodium or other deflocculating substances such as common salt, sodium silicate or soda ash.

5. Treatment with calcium or flocculating chemical substances such as hydrated lime and calcium chloride. The latter being highly deliquescent.

We in Minnesota have found that a well trained organization familiar with soil and subgrade survey is the first essential to the satisfactory building of the so-called "stabilized road" project. At the present time, the State Department of Highways has at least one soils engineer located in each of the eight construction districts. These men are in the charge of a chief soils engineer and his assistants, at the central office.

In addition to this corps of engineers, the laboratory is well equipped to perform routine tests or research work on such specimens of soil material as the district soils engineers may choose for study and analysis.

## Laboratory Tests of Soil Material

Prior to the construction of this type of road the soils engineers make a survey of the project, including a classification of soils in the subgrade and the natural soil profile. Should the road already be gravel surfaced, measurements are also taken of the amount of available gravel material which may be utilized and incorporated into the stabilized course.

Laboratory tests are then run by the technician in the laboratory so that the physical properties and gradation of the soil material may be obtained. These tests are normally followed by trial mixtures using the soil material and gravel in different proportions, and these mixtures are examined to determine the plasticity indexes.

Perhaps it may be well to mention at this time that the plasticity index is considered as a measure of cohesiveness.

Present practice in the state of Minnesota has been the construction of the class and type of stabilized road wherein the construction operations consists of placing

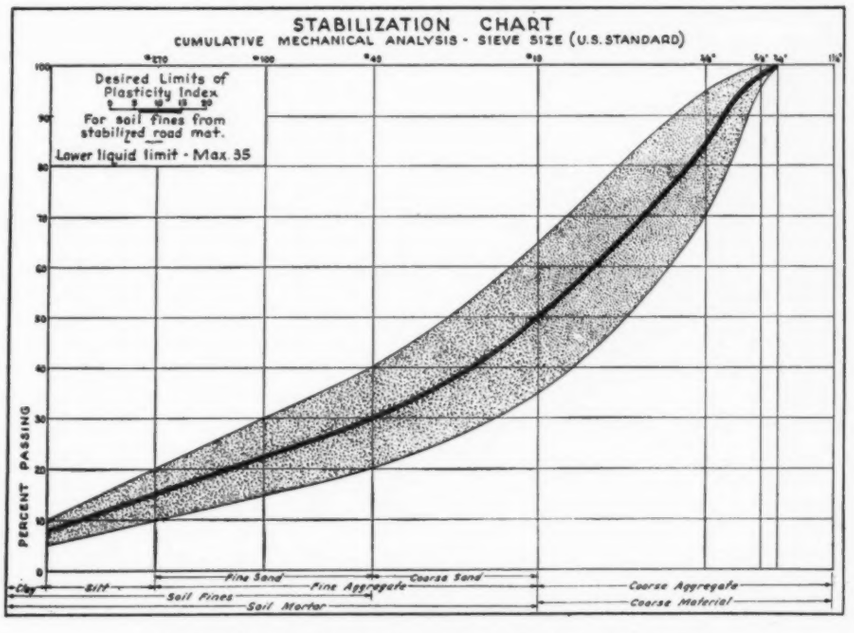


*Diagram Showing Percentage of Various Sizes of Aggregate and Soil Material Passing a Given Sieve Size.*

the gravel on the road in sufficient quantity to provide the recommended thickness and then incorporating the soil and clay binder by mixing operations.

On the bulk of the projects completed within the past year, a deliquescent salt, calcium chloride, was used to aid in compaction under rolling operations and in preserving a constant moisture content.

The accompanying diagram shows the percentage of the various sizes of aggregate and soil material passing a given sieve size. This diagram presents a band of gradations in the shaded area within which satisfactory mixtures may be obtained and a heavy line showing the theoretical ideal mixture as it is now known. It is possible that further research and study may somewhat change the theoretical ideal.

## The Plasticity Index

It may be noted from this diagram that the plasticity index of that portion of the mixture which passes a No. 40 sieve ranges from 6 to 15. We have, on occasion, found that where the mixtures are designed with the upper range of plasticity index and a considerable portion of fine material is also included, that they may develop some tendency to "slickness" of the surface when final compaction is obtained during a wet season.

The following tabulation of Class 2, 3, and 4 shows the percentages of aggregate in numerical form as practiced in Minnesota:

| Class | 2 | 3 | 4** |
|---|---|---|---|
| Use | Stabilized Gravel Surface | Stabilized Gravel Base | Gravel or Sand Base |
| Per cent passing 1¼" sieve. | | 100 | 100 |
| Per cent passing ¾" sieve.. | 100 | 80–100 | |
| Per cent passing ⅝" sieve.. | 95–100 | | |
| Per cent passing ⅜" sieve.. | 70–95 | 65–95 | 60–100 |
| Per cent passing No. 10 sieve | 35–65 | 30–65 | 25–100 |
| Per cent passing No. 40 sieve | 20–40* | 15–40 | |
| Per cent passing No. 100 sieve | 15–30 | 10–30 | 0–35 |
| Per cent passing No. 270 sieve | 10–20 | 6–20 | 0–20 |
| Fraction passing—Plasticity Index | 6–15 | 4–15 | Max. 10 |
| No. 40 sieve—Lower Liquid Limit | Max. 35 | Max. 35 | Max. 35 |

*The fraction passing the No. 40 sieve shall be not less than 40 per cent of the fraction passing the No. 10 sieve.

**If the Special Provisions for the project require the addition of binder soil and/or other aggregates, the final mixture shall conform to these requirements.

The thickness of the stabilized portion of the road surface may be designed from 3 to 12 in. This, of course, depends upon the type of subgrade material on which the stabilized mixtures are laid.

The Class 2 gradation is used on stabilized projects of three-inch thickness, and a combination of Class 2 and 3 or 4 is used on projects where greater thickness is desirable.

It is, perhaps, well to point out that the Class 4 material permits a much more sandy material than do either Class 2 or 3 and its use is permitted in the interest of economy in construction.

As a matter of fact, most of the mileage which we have built during the past year has consisted of a Class 4 materials of variable thickness underneath a Class 2 mixture of 3-in. thickness. Construction operations usually consist of first placing the loose gravel material into a windrow on one or both shoulders of the road, the subgrade having been first shaped, if necessary. Soil binder is then hauled in the proper amounts as required by the specifications and incorporated mechanically into the gravel material.

## Methods of Pulverization

It is often necessary to allow the soil binder to remain in windrows or spread upon the road surface for the purpose of drying, previous to incorporating into the gravel.

Some pulverization is obtained from traffic, but usually not sufficient to break the particles down completely. The process of pulverization has been accomplished by the use of harrows, serrated rollers, straight rollers, or soil pulverizers in conjunction with motor patrol blades. There is considerable room for improvement, both in equipment and method, as far as pulverization process is concerned. When the soil binder has been sufficiently pulverized the next step is to mix it with the gravel material. It is common practice to mix the materials in such quantity as to provide a 2 or 3-in. thickness. Where a 3-in. layer is being mixed, there is considerably more difficulty encountered in the compaction of the layer and additional efforts must be made to secure proper compaction.

When thorough mixing has been obtained, the material is spread out over the road surface and sprinkled with water, unless, by good fortune, a rain occurs at that time. It is perhaps unfortunate that, during the past year, many stabilized projects were built during the period of relative drouth and it was necessary in a few cases to haul as high as 60,000 gal. of water per mile.

On those projects on which calcium chloride is specified, about two-thirds of the total amount is used integrally with the mix and incorporated during the mixing operations, and the balance is placed as a surface application after the stabilized material has been thoroughly compaced.

Where calcium chloride is specified, the amount used is approximately five-tenths of a pound per square yard per inch of thickness. However, in no case has the deliquescent salt been utilized except in the top 3-in. portion of any project.

## Methods of Compaction

During the past year, a considerable amount of experimenting has been done in methods and equipment. One of the methods of compaction which appears most satisfactory is the use of a pneumatic tired roller. This device has a considerable advantage in that it provides a kneading action as well as straight compaction.

It may be said, in passing, that a thoroughly compacted stabilized mixture, if subjected to some traffic, may reach a density of over 150 lb. per cubic foot.

There is still room for improvement also in the equipment used in the mixing operation, although motor patrol blades and multiple blade mixers or traveling mixers of the pug-mill type have proved satisfactory alone or in combination.

During the past year, a stationary plant was used successfully in producing mixtures of the stabilized type and two experimental jobs were constructed with this unit: the first project being on Trunk Highway No. 36 from North St. Paul to 2½ miles northeast. This first project was entered upon to determine whether the stationary plant mix units were feasible. After the completion of this project it appeared that the use of this machine provided a very satisfactory mixture. After some modifications were made, the same machine was again used on an experimental project on Trunk High-

way No. 75 west of Ada. This project was sponsored jointly by the State of Minnesota and the Bureau of Public Roads, with, as its objective, a determination of the required thickness of the stabilized mixture necessary to carry traffic over a heavy gumbo soil.

On this experimental surfacing project, clay, fine sand, crushed gravel, calcium chloride and water were plant-mixed in proportionate quantities. The job was completed in the late fall. It comprised a 13.6 miles stretch of United States Highway 75 between Ada and Hendrum, Minn. This is the Winnipeg-Galveston route and carries a very considerable and increasing volume of international as well as local traffic. The work was done under contract by the Jack Roth Construction Co. of St. Paul, who were awarded the contract in May on their bid of $95,200, slightly more than $7,000 a mile for the job. There are 58,341 tons of gravel base and surfacing in the job. After the mix top has been thoroughly hardened, it may possibly be coated in 1937, with a mat of bituminous material. The surfacing was laid on the natural subgrade after removing the old bituminous mat, except for a 3-mile section of the road, on which the bituminous surface was left in place, and covered with the stabilized surfacing in order that the effect might be determined.

For experimental purposes, the job was divided into 16 sections and the depth of the course was varied from 1 to 8 in. Each section of the 16 has either a different depth or a different combination of material.

Clay was taken from pits 12 miles and 4 miles west of Ada and for one section from a pit 8 miles south of Twin Valley. Further experimenting was done by using clay taken from different depths in the pits.

The approximate combination of materials expressed in percentage is gravel, 75; clay, 11; fine sand, 6; water, 8; and calcium chloride 9 lb. per ton on surface course.

As this project was only recently completed, information on the desired thickness is not yet available.

## A Good Crown Is Essential

It was soon discovered that as a result of some of our early stabilized projects that a good crown to the surface was necessary in order that surface waters might be readily eliminated. Projects which did not carry a proper crown were subject to pitting and some raveling. It now appears that a crown of ½ in. to ⅝ in. per foot is satisfactory. Experience has shown that a stabilized wearing surface requires a different type of maintenance than that for loose bound surfaces. We have found that it is impossible to cut the surface during dry weather and any maintenance operations which are necessary must be accomplished when the course is wet. Such a condition allows such blading as is necessary to eliminate surface difficulties and also permits consolidation of any reshaped loose material under traffic.

Blading after rains is necessary to preserve proper riding qualities and in some cases it is necessary to augment the blading operations by hand patching where unusual conditions occur.

With reasonable maintenance, stabilized surfaces have given a good account of themselves under traffic, but their utility as a base for a higher type of surface should not be overlooked. Certainly they lend themselves admirably to a stage construction program of highway development.

As a matter of record, Minnesota has placed a considerable mileage of bituminous surfaces over the stabilized road projects. Such bituminous surfaces are, in

STABILIZED GRAVEL BASE PROJECTS COMPLETED IN 1936

| Location | Length Miles | Total Cost Base Construction | Cost Per Mile | Total Depth Base Constructed In. | Depth Base Stabilized In. |
|---|---|---|---|---|---|
| Bena—Federal Dam | 7.4 | $21,250 | $2,900 | 1 to 5* | 1 to 5† |
| Swan River | 10.4 | 66,900 | 6,430 | 6 to 12* | 6 or 9† |
| Mirbat | 8.2 | 42,500 | 5,190 | 6 to 12* | 6 or 9† |
| Remer | 14.0 | 67,200 | 4,800 | 3 to 9* | *† |
| Pelland—International Falls | 10.0 | 84,640 | 8,464 | 12 | 7 |
| Luxemburg—St. Cloud | 8.5 | 10,130 | 1,190 | 2** | 2** |
| Ivanhoe | 4.9 | 28,200 | 5,760 | 12 | 5 and 9† |
| W. Lyon Co. Line | 9.0 | 48,650 | 5,400 | 12 | 5 and 9† |
| Forest City | 6.6 | 31,500 | 4,780 | 2 to 24* | 2, 6 or 9† |
| Ericksburg | 11.4 | 78,000 | 6,850 | 3, 6, 9 or 12* | 3, 6, 9 or 12† |
| Ericksburg | 10.9 | 71,400 | 6,550 | 3, 6, 9 or 12* | 3, 6, 9 or 12† |
| Lowry—Glenwood | 6.7 | 34,700 | 5,180 | 2 and 12* | 2 and 9† |
| Kensington | 2.8 | 18,300 | 6,540 | 12 | 9 |
| Elbow Lake | 1.5 | 9,190 | 6,130 | 12 | 9 |
| Kensington—Lowry | 9.8 | 47,550 | 4,850 | 12 | 9 |
| Barrett | 12.3 | 45,000 | 3,660 | 2 and 12* | 2 and 9† |
| West Concord | 7.0 | 44,900 | 6,420 | 9 to 24* | 9 |
| Zumbrota—Goodhue | 7.9 | 44,850 | 5,680 | 3 and 6* | *† |
| Baptism River—Beaver Bay | 6.5 | 53,400 | 8,220 | 9†† | 9 |
| Nashwauk | 2.9 | 18,550 | 6,400 | 10 | 10 |
| Rapid River—Spooner | 12.6 | 81,700 | 6,480 | 6§ | 6 |
| Ada | 13.6 | 95,200 | 7,180 | 2, 3, 4, 6, 8* | *† |
| Hallock—Noyes | 19.3 | 93,300 | 4,830 | 6 | *† |
| Jct. T. H. No. 15—Cambria | 6.6 | 33,800 | 5,120 | 3 and 12* | 3 and 9† |
| Bennettville—Aitkin | 9.3 | 36,300 | 3,900 | 2 and 12* | 2 and 5†§§ |
| Jct. T. H. No. 18—Bennettville | 4.4 | 13,950 | 3,170 | 2 and 12* | 2 and 5†§§ |
| Pine River—Jenkins | 3.4 | 14,500 | 4,270 | 3 | 3§§ |

*Variable. †Varies. *†Entire depths stabilized. **Approximately. ††Varies—9 in. minimum. §Varies—6 in. minimum. §§Sand subgrade also.

TOTALS—Length in Miles: 227.9
Total Cost Base Construction: $1,235,560
Average Cost Per Mile: $5,420

Note.—These costs include all items chargeable to the gravel or sand base course construction. In some cases backfill for subgrade excavation is also included. Shouldering and regrading costs are not included. These costs are based on contract quantities and contract unit prices. [This was rearranged from figures given by Mr. Allen in his paper presented at the 1937 Convention of the American Road Builders' Association. Mr. Allen's paper also is printed herewith practically in full.—Ed.]

themselves, in most cases only an additional stage of work which when continued further will result in an improved system.

### Use Under Rigid-Type Pavements

The use of stabilized mixtures has also been tried under the rigid type of pavement where subgrade soil is of such a type that high joints or warping of the slab would occur. This experimental project, using stabilized mixtures, as a base, was placed on Trunk Highway No. 75, from Breckenridge to Doran.

As this project was only completed during the past season, no attempt will be made at this time to present the details of construction, nor the success of the base course.

The following tabulation shows the location, cost and thickness of projects completed during the 1936 season. It should be noted also, that in some cases the cost also included the elimination of frost heaves and frost boils.

During the season of 1936, approximately 250 miles of stabilized roads were constructed. The bulk of which were on the Federal Aid System and built in accordance with plans and specifications written by the State Department of Highways and approved by the Bureau of Public Roads.

▼

# FOREMAN'S INGENUITY KEEPS DOWN COST OF BRIDGE

INGENIOUS devices have been employed by many foremen on construction projects of the Works Progress Administration in various parts of the country. This fact is revealed by examination of many narrative reports from state WPA offices which have been received from time to time by the Information Service of the WPA at Washington, D. C., headquarters.

Harnessing the forces of nature to help, and thereby reducing the cost of a bridge construction project, is illustrated in the case of work recently done by a WPA foreman and his crew on Bear Creek, near Walsh, Colo. The very forces—flood water and sand silting—which it was feared would run up the expense of the project were in fact employed to speed up the work and reduce the expense.

*Dam Across Arroya Above Bridge Location.*

*Overhead Tram Used in Handling the Stone*

The bridge was constructed over Bear Creek, one mile north of Walsh on the Walsh-Holly road. It was a 4-barrel structure with 16-ft. arches of stone masonry. George Steen was the foreman.

Due to the sandy condition of the creek bed in times of flush run-off Bear Creek carries a heavy burden of sand. The foreman knew that if, while he was making his excavations for footings, a heavy rain caused a run-off in this stream the work would be lost unless expensive, sand-tight coffer dams were built. He threw a small dam across the arroya above the bridge location at a point where the flow of water over the crest of the dam would pitch down on the bottom of the aroya at the location of the foundation.

Rains did come and this run-off deposited above the dam more than enough sand for the construction work of the bridge while at the same time the water pitch over the dam excavated the field below to an average depth of less than 3 ft. above the footings of the bridge. This made it possible to easily excavate and start these footings with much of the work already done by the stream. The deposit of sand above the dam was handy for construction purposes. The materials used in the dam were then removed and completely salvaged for other purposes.

An additional ingenious operation was in the cutting and placing of the stone. For safe operation stone was cut ready for laying in the bridge on the high ground so that any freshet would not cause a loss. Then to facilitate the placement an overhead tram was rigged up between two tripods and an ordinary hay track car with a cable and bucket attached transported the stone from where it was cut to the foundation, by the use of an improvised gasoline hoist built from an automobile engine.

▼

*Index to A. S. T. M. Standards.*—The latest edition of the Index to American Society for Testing Material Standards and Tentative Standards is a 120-page publication giving information on all of the 796 standards as of Jan. 1, 1937. The index is of service to anyone wishing to ascertain whether the Society has issued standard specifications, test methods, or definitions covering a particular engineering material or subject and it is of help in locating the standards in the volumes where they appear. Copies of this publication are furnished without charge on written request of A. S. T. M. Headquarters, 260 S. Broad St., Philadelphia.

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EXCAVATING, DRILLING, AND MATERIAL HANDLING EQUIPMENT... SOUTH MILWAUKEE, WISCONSIN, U. S. A.

# FUNDAMENTAL ITEMS IN COUNTY ROAD MAINTENANCE

THE subject of maintenance of county roads is one involving innumerable problems and many variations in organization and in method. This is to a large extent caused by opposite extremes in climatic conditions, by traffic density and oftentimes by available funds. In most cases it is difficult to draw definite lines between what might be called maintenance and the field of reconstruction. In general, highway maintenance involves doing the things necessary to keep the roads as nearly as possible in its original state. An interesting report on the maintenance of county roads was presented at the 1937 convention of the American Road Builders' Association by the committee of which H. G. Sours, County Engineer, Summit County, Ohio, is chairman. The report, which is the result of a nation-wide survey, presents important and fundamental items of the subject as they appear to be done throughout the United States. Conclusions and recommendations drawn from them also are included, in the report which follows.

## Organization

In most counties where funds are available an engineer is in charge with a superintendent handling operations. This seems highly desirable and should be further broken down to district superintendents with gang foremen operating under them. A combination of the gang and patrol system seems to be the most practical plan, conditions governing the extent of each. The patrol works well for blading and dragging untreated roads and light patching of bituminous surfaces. For hard surface patching, ditch and shoulder work, the gang plan is generally used and seems to be the most practical.

It is desirable where a sufficient amount of work warrants it, to have some specialized floating gangs, such as bridge repair gangs, counterline and route making and guard rail gangs. A special patrol during the spring and fall and such other periods when damage is liable to be done to the roads, is oftentimes justified because it locates and repairs minor damages which might quickly result in something more serious.

The majority of the counties have the territory divided into districts. Where possible they have district headquarters, garages and yards. This is very desirable in that it centers activities in each district and eliminates a considerable amount of wasted time and expense involved when operating out of one central headquarters. In most cases, however, the repair and overhauling of equipment is done in a central headquarters. Emergency repair work is sometimes done in the district garages.

## Operations

There seems to be considerable variation in the number of hours worked per week. The 8-hour day perhaps applies to the majority of the counties although some of them go as high as 9 or 10 hours per day. Very few counties work less than five and some work six days per week. It is to be noted, that around the large industrial centers, the 40-hour week prevails and in some of the remote and rural sections, the hours per week are the highest. The local conditions, with respect

*An Iowa State Maintenance Crew Repairing a Blow-Up.*
*This Work Should Delight an Efficiency Expert, for With Its Well-Adapted Equipment the Crew Makes Remarkable Speed in Cutting Out the Damaged Slab, Placing New Concrete, and Moving on to the Next Job.*
**Photo by Field Editor**

to unemployment, are no doubt reflected in the number of hours worked on the roads. The 6-hour day, now in effect in many industries, does not seem practical in road maintenance on account of the scattered nature of operations and particularly in the north where the seasonal conditions require certain things to be done in a limited length of time.

No indication of uniformity has been found in the matter of reduction of activities during the winter season in the northern counties. Some reduce hours per week, some maintain the same hours and reduce forces, some do both and a few continue the same schedule throughout. In the southern states, this condition does not enter into the problem and they are able to maintain uniform working conditions throughout the year.

It is difficult to make recommendations on these particular phases on account of widely different governing factors and conditions. Generally speaking, however, it would seem that the 8-hour day and 5-day per week, would be practical in densely populated counties and industrial centers. This keeps the men off the road on Saturday when traffic is heavy and does not seriously conflict with industrial schedules of working hours. In the rural counties where labor and employment conditions are different, as well as traffic, longer hours may be justified. As to winter reduction, conditions again have considerable bearing. Where unemployment is not serious, it is better to lay off men and maintain the hours. On the other hand, where unemployment is a serious problem, there is considerable justification in shortening the number of hours per week and to keep the forces more nearly intact.

## Force Account Versus Contract

Practically everything which is classed strictly as maintenance, is done by force account. It is where we get into the field of resurfacing and reconstruction that we find a difference in opinion and in practice. In the majority of cases, the application of bituminous materials on surface treatment work is done by contract, although there are some counties which are equipped with facilities to do their own applying. Many engineers prefer to do everything other than the application by force account, stating that they can do the job better and cheaper. Others say that they do not want to equip themselves for this class of work and can do cheaper and better work by contract.

There is something to be said on both sides of this question. When light treatments are being applied, the desirable plan would seem to be to contract the furnishing and application of the bituminous materials and to do the sweeping and the spreading of the cover material by force account. On resurfacing work, it would seem that the properly equipped and trained contractor should be able to handle the work more satisfactorily, considering everything.

It is reasonable to assume that in many cases where the counties have been doing their resurfacing work by force account, they have established this practice by reason of the fact that considerable experimentation has taken place, resulting in changes being made during the construction, which are more or less inconvenient to handle by contract. As a result of this, many of the county organizations have become quite proficient in this class of work and in those particular counties, contractors have not had the opportunity to develop trained organizations to handle the work.

In the case of plant mixes, it is hard to conceive that any county would be justified in owning and operating a plant of their own and this work should be done by contract.

## Equipment

Practically all counties own their own equipment except certain heavy pieces such as power shovels and cranes, which are rented occasionally. The same applies to the renting of trucks which is occasionally done when an unusual amount of hauling has to be done in a short time.

A wide variance of opinion seems to prevail on the size of trucks, but in general the most used among the newer trucks, is in the 2 to 3-ton class. There are definite uses, however, for the smaller as well as the larger units. The majority of the engineers favor the trading in and replacing of equipment, before heavy repairs are involved.

## Hard Surface Types

The practice with respect to repairs of the various hard surface types, seems in general to be to do the necessary patching with the same type of material as was incorporated in the original pavement. This practice is recommended and should not be deviated from with the exception of emergency work where cold patch material may be used on practically any type. The same thing might be said about using a different type of patching material in the case of temporary repairs of old pavements which will undoubtedly either be reconstructed or resurfaced some time in the near future.

The proper time to seal cracks in pavements is in the spring and fall when the cracks are open as a result of the pavement being contracted and weather conditions are suitable for pouring of the cracks. Both tar and asphalt are used for this purpose, the joint usually being covered with sand or fine aggregate.

A field which has been entered recently in a few places, is that of the stabilization of shoulders along hard surface pavements. Shoulder maintenance is one of the expensive and continuous problems where traffic is heavy. In some localities where sod shoulders have been satisfactory, the problem has been more or less solved in that manner. However, where the traffic is of such a nature and amount that the shoulders are being used to a considerable extent, something should be done to solve the problem of building and maintaining satisfactory shoulders. The answer seems to be in shoulder stabilization and with its vast possibilities, undoubtedly this field will be opened up to a great extent during the next few years.

## Bituminous Treated and Road Mix Types

There is a considerable variance of opinion as to what should be done with traffic bound bases. Some engineers favor starting out with light treatments and gradually building them up over a period of years. The argument in favor of this is that after the first year of service they will be able to determine whether or not this type will carry through or if it will be necessary to follow up with a heavier top. On the other hand, some are of the opinion that very few traffic bound bases are sufficient to carry light treatments and that a heavier top should be put on to begin with. There is no definite recommendation to be made in this respect on account of the fact that there are so many variable conditions involving such matters as the value of the base, sub-

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grade conditions, volume and nature of traffic and climatic conditions. Experience with the different types under the various conditions alone will tell what is the proper thing to do.

One of the puzzling questions which confronts the county engineer, is what should be done with traffic bound bases which have been worn to such an extent that there is some question about satisfactorily supporting a bituminous top. The answer, in most cases, seems to be that the base course should be rebuilt and strengthened, finishing off with a lighter bituminous top rather than to attempt to build up all of the strength by constructing a heavy bituminous top. Some very satisfactory work has been done in rebuilding bases by compacting crushed gravel with a sufficient amount of fines to properly bind the aggregate. After proper compaction it may be primed and surfaced. In other cases, particularly where the traffic is heavy, a four-inch waterbound macadam course, finished off with a light bituminous top has proven to be an excellent pavement.

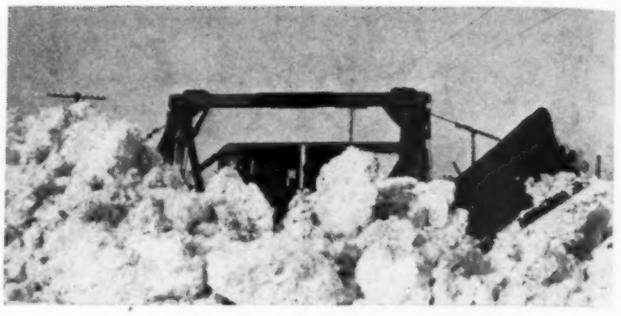
Road mixes vary in thickness, but it is generally conceded that 2½ in. compacted is about the maximum which can be handled successfully and obtain the proper smoothness. In some cases thicker tops have been successfully laid by constructing in them two courses, using a coarse aggregate in the base course and finishing off with a light top, using smaller aggregate.

## Untreated and Low-Cost Types

The practice in general, in the maintenance of untreated types is to maintain practically a bare surface during the summer months and to carry a layer of floating material in the spring and fall when conditions are such that some aggregate may be worked into the pavement. Where dust layers are being used, it is especially advantageous to have the surface free from any material which might act as an abrasive tending to ravel the surface.

Dust layers have been used to a considerable extent in many of the counties and the results have been very satisfactory. The principal materials which have been used are calcium chloride and road oils. In dust laying the material used should produce a surface which is well compacted but at the same time will under certain weather conditions, permit the floating and light blading of the surface. The question is sometimes raised, as to whether or not a county can afford to use dust laying materials. Careful observations and studies seem to prove that the cost of dust laying materials does not exceed the cost of a material which is lost off the surface of the road during a season. It would seem logical to spend the required funds to save the material from being dusted off and at the same time to provide the comfort and convenience not only to the users of the road but to the people whose homes are along the highway.

Quite a number of counties are now entering into the field of stabilization of low-cost roads. This process has made it possible to make good use of many local materials, which a few years ago were not considered to be satisfactory for road construction. Another advantage of this type of construction is that the maintenance costs are very low compared to the old traffic bound type. This is due to the fact that the surface is bound and does not require the continual blading and dragging and the addition of materials from time to time. The maintenance of this type of road is not particularly difficult if the correct methods are followed. This field seems to have enormous possibilities for counties, particularly where they do not have sufficient funds to build higher types and on certain roads in all counties where they are in need of low-cost construction and maintenance.



*Remember Last Year? Here's What They Were Doing March 7, 1936, in Waukesha County, Wisconsin. The Heavy Snow Was Too Much for One Bite, So the Caterpillar-La Plant-Choate Combination Was Coming Up to Slice Off the Top.*

## Snow and Ice Removal

The majority of the counties where snow and ice is a serious problem, keep certain men in their maintenance departments under standing orders to start plowing snow and to take care of icy conditions at such times as are necessary, rather than to await orders to be issued from a central or district headquarters. This seems to be the most efficient plan for prompt service.

One matter which should be given careful attention is that wherever possible, the snow should be plowed completely off the shoulders and into the ditches. This should be done for two reasons; the first being that it makes room for snows that follow and the second is that when the snow melts, the water is where it belongs rather than lying along the edges of the pavement and on the shoulder where it will do considerable damage.

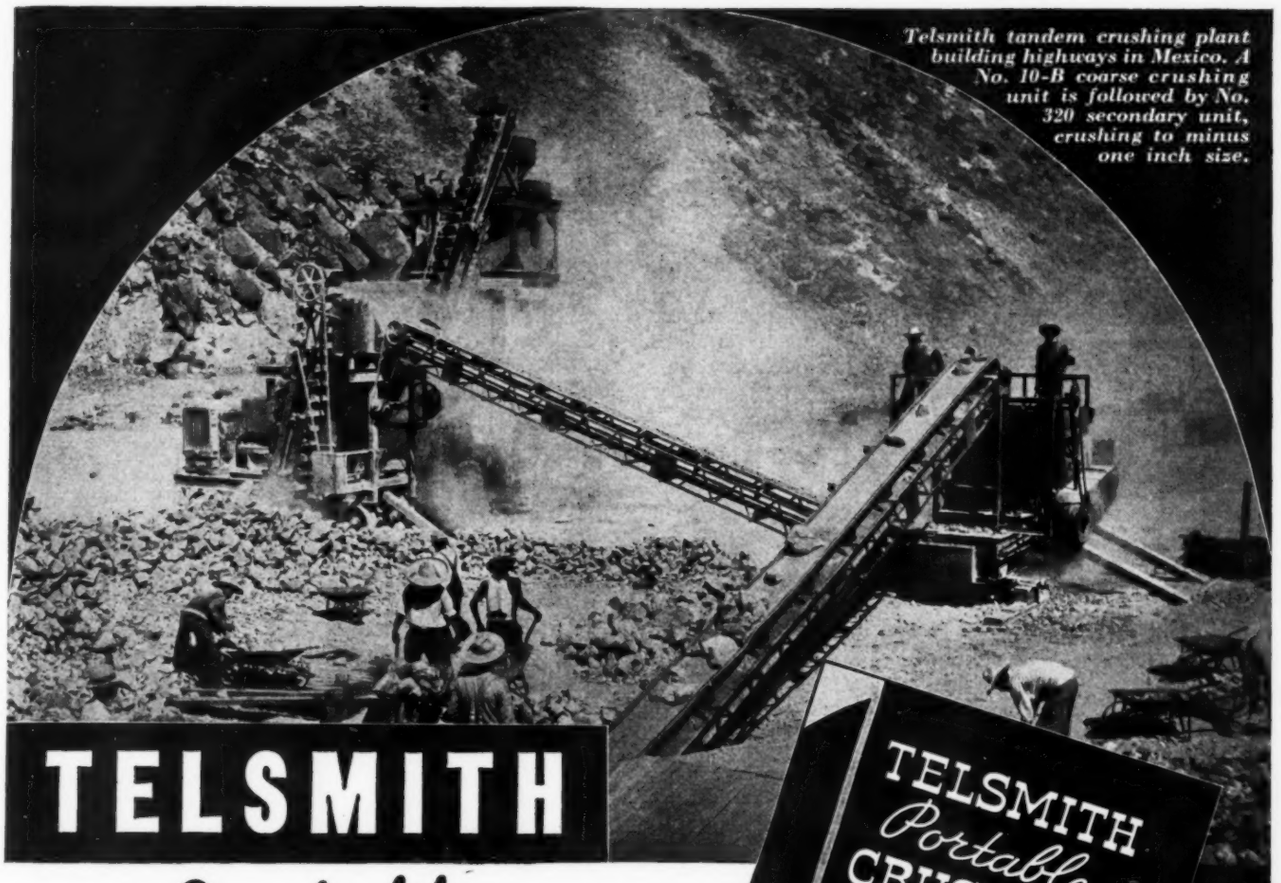
Practically all counties use precautions against icy pavements; the majority of them use calcium chloride or salt mixed with sand, grit or cinders. Some counties have followed the practice of treating their roads, especially the main traveled ones throughout their entire length. The majority, however, have not yet progressed to that point but take care of all dangerous places on the road.

## Roadside Beautification

There is a distinct difference in what might be termed roadside beautification merely for the purpose of adding to the attractiveness of the road and beautification which has along with it, some practical value. While some counties are doing some of the former, the majority of this class of work where it is being done at all is in the nature of sodding of shoulders and slopes, together with the planting of various kinds of vines and shrubs, particularly on the high slopes in cut and fill, for the purpose of preventing erosion.

A little experience with this type of work will readily prove that the cost of doing planting to prevent erosion is soon offset by the saving in maintenance.

To start out, the average county will have to buy its own nursery stock, but it is surprising how cheaply the various types may be grown and any considerable program of this kind of work would justify the county in growing its own stock.



*Telsmith tandem crushing plant building highways in Mexico. A No. 10-B coarse crushing unit is followed by No. 320 secondary unit, crushing to minus one inch size.*

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# COMPARATIVE INFORMATION ON ROAD-BUILDING EQUIPMENT

THIS is a continuation of the tables published in the January and February issues of ROADS AND STREETS. As stated in the January issue, they are not to be considered as a complete specification material. We ask that the tables be used more as guides in discussions than for selecting equipment. Manufacturers of equipment should be contacted in cases where purchase of new equipment is involved. New models and improvements to older units occur constantly so that what is listed here may not be the latest at the time purchase is contemplated.

The data given in the tables were supplied by manufacturers, assembled by us and returned to manufacturers for their approval. The larger and stationary types of centrifugal pumps were omitted because they are not included under "Contractors' Pumps." Instructions for selecting pump sizes are contained in the February issue. Engine tables will be continued next month.

## CONTRACTORS' DIAPHRAGM PUMPS

The ratings and capacities as given in the tables following are those sent to us by the manufacturers of this type pump. They are manufacturers' statements.

### No. 3 Single and Double — Lift and Force Type

| | No. 3 Single | No. 3 Double |
|---|---|---|
| Size of suction and discharge openings | 3 In. | 3 In. |
| Maximum Suction Lift | 23 Ft. | 25 Ft. |
| Maximum Discharge Head | Ft.* | Ft.* |
| Capacity in Gallons Per Hour | 3000-4000 | 6000-8000 |

*Dependent upon engine horsepower. Ranges from 10 to 30 feet.

| Manufacturer | Outfit No. Single | Outfit No. Double | Engine Make | H.P. | R.P.M. | How Mounted | Weight Lb. |
|---|---|---|---|---|---|---|---|
| Barnes Manufacturing Company | S305 | ..... | Stover | 2½ | 675 | Truck | 880 |
| Chain Belt Company | 3DH | ..... | Stover | 1½ | 600 | Trailer | 525 |
| C. H. & E. Manufacturing Co. | No. 5 | ..... | Stover | 2 | 550 | 2 Wheel Truck* | 700 |
| | *2 steel wheel spring mounted Trailer—also solid or pneumatic Tires. | | | | | | |
| Edson Corporation | 3RM1 | ..... | "Model 1V" | 2 | ... | 4 Wheel Truck* | 900 |
| | ..... | 3RM2 | "Model V" | 3 | ... | 4 Wheel Truck* | 1530 |
| | *Can be mounted on 2 wheel rubber tired trailer. | | | | | | |
| Marlow Pumps | 301 | ..... | Stover | 2-2½ | 575 | 4 Wheel Truck | 750 |
| | ..... | 331 | Stover | 3½ | 550 | 4 Wheel Truck | 1060 |
| | ..... | 331 | Le Roi | 5-6 | 1200 | 4 Wheel Truck | 1100 |
| Jaeger Machine Co. | 3AY | ..... | Stover | 2-2½ | ... | 4 Wheel Truck | 950 |

### No. 4 Single and Double — Lift and Force Type

| | No. 4 Single | No. 4 Double |
|---|---|---|
| Size of suction and discharge openings | 4 In. | 4 In. |
| Maximum Suction Lift | 23 Ft. | 25 Ft. |
| Maximum Discharge Head | Ft.* | Ft.* |
| Capacity in Gallons Per Hour | 6000-8000 | 12000-16000 |

*Dependent upon engine horsepower. Ranges from 10 to 30 feet.

| Manufacturer | Outfit No. Single | Outfit No. Double | Engine Make | H.P. | R.P.M. | How Mounted | Weight Lb. |
|---|---|---|---|---|---|---|---|
| Barnes Manufacturing Company | Single | ..... | Stover | 2½ | 675 | Truck | 1100 |
| | Single | ..... | Le Roi | 4 | 600 | Truck | 1200 |
| | ..... | Double | Le Roi | 5 | 600 | Truck | 1600 |
| | ..... | Double | Le Roi | 6 | 600 | Truck | 1800 |
| Chain Belt Company | 4DH | ..... | Stover | 2 | 600 | Trailer | 750 |
| | ..... | 4DDH | Stover | 3 | 600 | Trailer | 1250 |
| C. H. & E. Manufacturing Co. | No. 5 | ..... | Stover | 2 | 550 | 4 Wheel Truck* | 700 |
| | No. 6 | ..... | Stover | 2 | 800-1500 | or 2 wheel | 875 |
| | No. 7 | ..... | Stover | 4 | 800-1500 | Trailer | 975 |
| | ..... | No. 8 | Stover | 4 | 800-1500 | 4 Wheel Truck** | 1400 |
| | *2 steel wheel spring mounted trailer, or 4 wheel truck. **Also solid or pneumatic tires. | | | | | | |
| Edson Corporation | 4RM1 | ..... | Vertical | 2 | ... | 4 Wheel Truck* | 975 |
| | ..... | 4RM2 | Vertical | 3 | ... | 4 Wheel Truck* | 1680 |
| | *Can be mounted on 2 wheel trailer. | | | | | | |
| Jaeger Machine Co. | 4AY* | ..... | Stover | 2½ | ... | 4 Wheel Truck | 950 |
| | 4AYJ* | ..... | Wisconsin | 6 | ... | 4 Wheel Truck | 1150 |
| | ..... | 4YYF* | Stover | 3½ | ... | 4 Wheel Truck | 1650 |
| | ..... | 4YYJ* | Wisconsin | 6 | ... | 4 Wheel Truck | 1700 |
| | *Convertible to open top. | | | | | | |
| Marlow Pumps | 401 | ..... | Stover | 2 | 575 | 4 Wheel Truck | 880 |
| | 401 | ..... | Stover | 3½ | 550 | 4 Wheel Truck | 930 |
| | ..... | 441 | Le Roi | 6 | 1200 | 4 Wheel Truck | 1700 |
| Novo Engine Co. | 31C | ..... | Novo | 3 | ... | 4 Wheel Truck | 1020 |
| | 61C | ..... | Novo | 6 | ... | 4 Wheel Truck | 1120 |
| | ..... | 42C | Novo | 4-5 | ... | 4 Wheel Truck | 1375 |
| | ..... | 62C | Novo | 6 | ... | 4 Wheel Truck | 1475 |
| | *Can be mounted on two wheels. | | | | | | |

## PRESSURE DISPLACEMENT PUMPS

The ratings and capacities as given in this table are those sent to us by manufacturers of this type of pump. They are manufacturers' statements.

| Manufacturer | How Driven Texrope Direct Twin Clutch | Make of Engine | Engine H.P. | Capacity G.P.M. 125 lb. Pressure | Size Suction In. | Size Disch. In. | Max. Working Pressure Lb. | No. of Cylinders | Total Weight Lb. |
|---|---|---|---|---|---|---|---|---|---|
| C. H. & E. Mfg. Co. | Texrope | Wisc. | 3 | 25 | 1½ | 1½ | 85 | 1 | 675 |
| | Open Gear | Le Roi | 12 | 40 | 2 | 2 | 150 | 3 | 2160 |
| | Enclosed Gear Reduction and Clutch | Le Roi | 15 | 40 | 2 | 2 | 400 | 3 | 2800 |
| | Clutch and Texrope | Waukesha | 50 | 80-125 Variable | 3 | 3 | 700 | 3 | 4200 |
| | Open Gear | Le Roi | 15 | 250 | 4 | 4 | 65 | 3 | 2750 |
| Domestic Engine & Pump Co. | Direct | Hercules | 10 | 55 | 2½ | 2½ | 175 | 2 | 1550 |
| | Direct | Le Roi | 20 | 80 | 3 | 2½ | 300 | 3 | 2700 |
| | Direct | Waukesha | 40 | 100 | 3 | 3 | 500 | 3 | 4500 |
| | Direct | Waukesha | 40 | 200 | 3 | 3 | 175 | 6 | 5600 |
| | Direct | Waukesha | 40 | 300 | 4 | 4 | 125 | 6 | 5600 |
| | Direct | Waukesha | 40 | 80 | 3 | 3 | 500 | 3 | 4500 |
| Fairbanks Morse & Co. | Clutch or V-Belt | Z | 2 | 14 | 2 | 2 | 300 | 1 | 685 |
| | Clutch or V-Belt | Z | 3 | 21 | 2 | 2 | 250 | 1 | 740 |
| | Clutch or V-Belt | Z | 6 | 29 | 2 | 2 | 175 | 1 | 1140 |
| | Clutch or V-Belt | Z | 6 | 42 | 2 | 2 | 250 | 2 | 1360 |
| | Clutch or V-Belt | Z | 6 | 53 | 2 | 2 | 175 | 2 | 1360 |
| | Clutch or V-Belt | Z | 10 | 71 | 3 | 2 | 350 | 2 | 3000 |
| | Clutch or V-Belt | Z | 10 | 93 | 3 | 2 | 270 | 2 | 3000 |
| | Clutch or V-Belt | Z | 15 | 148 | 4 | 3 | 125 | 2 | 3500 |
| | *H.P. indicated is for 125 pounds pressure. | | | | | | | | |
| The Gorman-Rupp Co. | Twin Disc Clutch | Hercules | 35-40 | 80 | 3 | 3 | 500 | 3 | 4000 |
| | Twin Disc Clutch | Hercules | 55-60 | 100 | 4 | 3 | 600 | 3 | 4200 |
| | Twin Disc Clutch | Hercules | 55-60 | 125 | 4 | 3 | 475 | 3 | 4200 |
| Novo Engine Co. | Chain | Novo | 2 | 15.7 | 1 | 1 | 125 | 1 | 250 |
| | Chain | Novo | 2 | 28.5 | 2 | 2 | 75 | 1 | 270 |
| | Chain | Novo | 2 | 51 | 2 | 2 | 40 | 1 | 270 |
| | Direct | Novo | 3 | 46 | 2 | 2 | 200 | 1 | 465 |
| | Direct | Novo | 4 | 46 | 2 | 2 | 185 | 1 | 465 |
| | Direct | Novo | 6 | 46 | 2 | 2 | 225 | 1 | 525 |
| | Direct | Novo | 8 | 46 | 2 | 2 | 180 | 1 | 525 |
| | V-Belt | Novo | 6 | 53 | 3 | 3 | 108 | 2 | 950 |
| | V-Belt | Novo | 8 | 55 | 3 | 3 | 144 | 2 | 950 |
| | V-Belt | Novo | 12 | 53 | 3 | 3 | 200 | 2 | 1155 |
| | V-Belt | Novo | 16 | 94 | 3 | 3 | 174 | 2 | 1350 |
| | Gear | Novo | 6 | 15 | 2 | 2 | 400 | 1 | 1248 |
| | Gear | Novo | 6 | 25 | 2 | 2 | 250 | 1 | 1248 |
| | Gear | Novo | 8 | 40 | 2 | 2 | 225 | 1 | 1248 |
| | Clutch | Novo | 20 | 40 | 2 | 2 | 400 | 2 | 2110 |
| | Clutch | Novo | 12 | 50 | 2½ | 2½ | 215 | 2 | 1965 |
| | Clutch | Novo | 20 | 60 | 2½ | 2½ | 300 | 2 | 2115 |
| | Clutch | Buda | 25 | 60 | 2½ | 2½ | 350 | 2 | 2300 |
| | Clutch | Novo | 12 | 110 | 3 | 3 | 125 | 2 | 1965 |
| | Clutch | Novo | 20 | 80 | 3 | 3 | 200 | 2 | 2115 |
| | Clutch | Buda | 25 | 80 | 3 | 3 | 300 | 2 | 2300 |
| | Clutch | Buda | 43 | 80 | 3 | 3 | 500 | 3 | 4325 |
| | Clutch | Buda | 50 | 125 | 3 | 3 | 320 | 3 | 4325 |
| | Note.—All capacities are given at pressure shown. | | | | | | | | |

## CONTRACTORS' INTERNAL COMBUSTION ENGINES

### 1 to 20 H.P.

| Manufacturer | Model | Fuel Used | No. Cyl. | Rated H.P. | Bore and Stroke | R.P.M. | Weight lbs. |
|---|---|---|---|---|---|---|---|
| Briggs & Stratton | H | Gasoline | 1 | ½ | 2¼ × 2¼ | 1750 | 53 |
| | A | Gasoline | 1 | 1 | 2¼ × 2¼ | 2200 | 79 |
| | B | Gasoline | 1 | 2 | 2⅝ × 2⅝ | 2400 | 96 |
| | K | Gasoline | 1 | 3 | 2¾ × 3¼ | 2400 | 132 |
| | Z | Gasoline | 1 | 4 | 3 × 3¼ | 2400 | 134 |
| Fairbanks Morse & Co. | .... | Gasoline* | 1 | 1½ | 2¼ × 3¼ | 1500 | 160 |
| | .... | Gasoline | 1 | 2 | 3½ × 5 | 600 | 245 |
| | .... | Gasoline | 1 | 3 | 3⅝ × 5 | 800 | 305 |
| | .... | Gasoline | 1 | 5 | 4⅜ × 6 | 600 | 490 |
| | .... | Gasoline | 1 | 7½ | 5¾ × 8 | 550 | 900 |
| | .... | Gasoline | 4 | 9.2 | 2⅝ × 3 | 1800 | 450 |
| | .... | Gasoline | 4 | 13.0 | 2½ × 4 | 1800 | 560 |
| | .... | Gasoline | 4 | 17.8 | 3 × 4 | 1800 | 630 |
| | *All above engines use either Gasoline or Kerosene. | | | | | | |
| The Lauson Company | ....* | Gasoline | 1 | ¾ | 1¾ × 1⅞ | 3600 | 26 |
| | ....* | Gasoline | 1 | 1 | 2¼ × 2¼ | 1800 | 72 |
| | ....* | Gasoline | 1 | 2 | 2⅝ × 2½ | 1800 | 85 |
| | ....* | Gasoline | 1 | 3 | 2¾ × 3¼ | 1800 | 170 |
| | ....** | Gasoline | 1 | 2½ | 2⅝ × 2½ | 1800 | 85 |
| | ....** | Gasoline | 1 | 5 | 3 × 3¼ | 1800 | 225 |
| | *Vertical Air Cooled Models. **Vertical Water Cooled Models. | | | | | | |
| Le Roi Company | .... | Gasoline* | 2 | 6 | 2¾ × 3½ | 1800 | 425 |
| | .... | Gasoline | 2 | 7 | 2⅞ × 3½ | 1800 | 425 |
| | .... | Gasoline | 2 | 7 | 3⅛ × 4 | 1200 | 465 |
| | .... | Gasoline | 2 | 8 | 3⅛ × 4½ | 1200 | 450 |
| | .... | Gasoline | 2 | 10 | 3⅜ × 4½ | 1200 | 450 |
| | .... | Gasoline | 4 | 12 | 2¾ × 3½ | 1800 | 520 |
| | .... | Gasoline | 4 | 14 | 2⅞ × 3½ | 1800 | 520 |
| | .... | Gasoline | 4 | 12 | 3¼ × 4 | 1200 | 565 |
| | .... | Gasoline | 4 | 15 | 3⅛ × 4½ | 1200 | 635 |
| | *All Gasoline burning engines may be equipped to use natural or manufactured gas. | | | | | | |


## CONCRETE'S RESISTANCE TO "SPRING BREAK-UPS" IS WORTH MILLIONS TO TAXPAYERS EVERY YEAR

WHEN the frost comes out or the rain pours down, concrete's sterling value becomes outstanding because softened subgrades *hold no terrors for concrete.*

Even though the past winter in some localities has not been severe, spring thaws or rains are again putting thousands of miles of roads to a test. And concrete is again proving it can stand the gaff without heavy maintenance and costly rebuilding. For concrete's beam strength bridges over soft subgrades, distributes the loads and so keeps the pressure on weakened subgrades within safe limits. Even after being subjected to severe frost heaving and continuous traffic over badly softened subgrades, routine inexpensive maintenance quickly puts concrete in prime condition for heavy summer traffic.

There is little or no interruption of service. Annoying detours and costly delays are avoided. Concrete is safe, economical, usable, in all seasons, rain or shine, day or night.

Drive your roads this spring and compare. Then build your new roads with dependable all-season concrete.

**PORTLAND CEMENT ASSOCIATION**

**Dept. 3-28, 33 West Grand Avenue, Chicago, Ill.**

## CONTRACTORS' INTERNAL COMBUSTION ENGINES—Continued

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Novo Engine Company | .... | Gasoline* | 1 | 2 | 2¾ × 2¾ | 2000 | | 97 |
| | .... | Gasoline | 1 | 2-3 | 2¾ × 3½ | 1800 | | 150 |
| | .... | Gasoline | 1 | 3 | 3 × 4 | 1800 | | 265 |
| | .... | Gasoline | 1 | 4-5 | 3⅜ × 4 | 1800 | | 265 |
| | .... | Gasoline | 2 | 6 | 3 × 4 | 1800 | | 330 |
| | .... | Gasoline | 2 | 8 | 3⅜ × 4 | 1800 | | 330 |
| | .... | Gasoline | 4 | 10-14 | 2¾ × 4 | 1800 | | 420 |
| | .... | Gasoline | 4 | 16-20 | 3⅜ × 4 | 1800 | | 510 |

*All of above gasoline burning units may be equipped to use Kerosene, natural or manufactured gas.

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Wisconsin Motors Corporation | AA | Gasoline* | 1 | 9. -1.8 | 2¼ × 2¾ | 14/2600 | | 68 |
| | AB | Gasoline | 1 | 1¾ -2.9 | 2½ × 2¾ | 14/2600 | | 68 |
| | AD | Gasoline | 1 | 2.1-3.7 | 2¾ × 3¼ | 12/2400 | | 150 |
| | AE | Gasoline | 1 | 2.5-4.2 | 3 × 3¼ | 12/2400 | | 155 |
| | AF | Gasoline | 1 | 3.9-5.4 | 3¼ × 4 | 12/2000 | | 195 |
| | AG | Gasoline | 1 | 4.5-6.1 | 3½ × 4 | 12/2000 | | 200 |
| | AH | Gasoline | 1 | 5.0-8.0 | 3⅝ × 4 | 12/2200 | | 205 |
| | AC4 | Gasoline | 4 | 7. -16 | 2⅝ × 3¼ | 10/2600 | | 230-290 |

*Oil burning equipment can be furnished with Models AD, AE, AF, AG, AH, and AC4 Engines.

## CONTRACTORS' INDUSTRIAL ENGINES—POWER UNITS

### 20 to 300 H.P.

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Allis Chalmers Mfg. Co. | W25 | Gasoline[1] | 31 | 4 | 4 × 4 | 1300 | 128 ... | 990 |
| | U40 | Gasoline[1] | 45 | 4 | 4½ × 5 | 1200 | 198 ... | 1755 |
| | E60 | Gasoline[2] | 68 | 4 | 5¼ × 6½ | 1050 | 340 ... | 2700 |
| | L90 | Gasoline[3] | 102 | 6 | 5¼ × 6½ | 1050 | 520 ... | 4450 |
| | E060 | Diesel | 70 | 4 | 5¼ × 6½ | 1050 | 350 ... | 2775 |
| | L090 | Diesel | 107 | 6 | 5¼ × 6½ | 1050 | 535 ... | 4550 |

[1]Also Distillate or Natural Gas. [2]Also Distillate, Natural Gas or Butane. [3]Also Natural Gas or Butane.

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Atlas Imperial Diesel Engine Co. | 2AN115 | Diesel | 18 | 2 | 4¾ × 6½ | 1000 | 95 ... | 1800 |
| | 4AN115 | Diesel | 40 | 4 | 4¾ × 6½ | 1000 | 210 ... | 2215 |
| | 3EN226 | Diesel | 45 | 3 | 6 × 8 | 700 | 337 ... | 3650 |
| | 4EN226 | Diesel | 60 | 4 | 6 × 8 | 700 | 450 ... | 4060 |
| | 6EN226 | iDesel | 90 | 6 | 6 × 8 | 700 | 674 ... | 5440 |
| | 4EN327 | Diesel | 80 | 4 | 7 × 8½ | 650 | 647 ... | 4700 |
| | 6EN327 | Diesel | 120 | 6 | 7 × 8½ | 650 | 970 ... | 6600 |
| | 6EN668 | Diesel | 200 | 6 | 9 × 10½ | 514 | 2040 ... | 13700 |
| | 8EN668 | Diesel | 275 | 8 | 9 × 10½ | 514 | 2800 ... | 18500 |

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Buda Engine Company*** | H205 | Gasoline | 205 cu. in. | 4 | 3⅛ × 4½ | .... | .... ... | .... |
| | H217 | Gasoline | 217 | 4 | 3⅛ × 4¾ | .... | .... ... | .... |
| | H260 | Gasoline | 260 | 6 | 3½ × 4½ | .... | .... ... | .... |
| | H298 | Gasoline | 298 | 6 | 3¾ × 4½ | .... | .... ... | .... |
| | H326 | Gasoline | 326 | 6 | 3⅛ × 4¾ | .... | .... ... | .... |
| | K369 | Gasoline | 369 | 6 | 4⅛ × 4¾ | .... | .... ... | .... |
| | K393 | Gasoline | 393 | 6 | 4⅛ × 4¾ | .... | .... ... | .... |
| | K428 | Gasoline | 428 | 6 | 4⅜ × 4¾ | .... | .... ... | .... |
| | L468 | Gasoline | 468 | 6 | 4¼ × 5½ | .... | .... ... | .... |
| | L525 | Gasoline | 525 | 6 | 4½ × 5½ | .... | .... ... | .... |
| | GF638 | Gasoline | 638 | 6 | 4¾ × 6 | .... | .... ... | .... |
| | JV6 | Gasoline | 1130 | 6 | 5¾ × 7¼ | .... | .... ... | .... |
| | JK6 | Gasoline | 1230 | 6 | 6 × 7¼ | .... | .... ... | .... |
| | 4-D-186 | Diesel | 186 | 4 | 3⅝ × 4½ | .... | .... ... | .... |
| | 4-LD-196 | Diesel | 196 | 4 | 3⅝ × 4¾ | .... | .... ... | .... |
| | 6-LD-275 | Diesel | 275 | 6 | 3½ × 4¾ | .... | .... ... | .... |
| | 6-LD-415 | Diesel | 415 | 6 | 4 × 5½ | .... | .... ... | .... |
| | 6-LD-468 | Diesel | 468 | 6 | 4¼ × 5½ | .... | .... ... | .... |
| | 6-LD-691 | Diesel | 691 | 6 | 4¾ × 6½ | .... | .... ... | .... |
| | 6-LD-909 | Diesel | 909 | 6 | 5¼ × 7 | .... | .... ... | .... |
| | 6-LD-1611 | Diesel | 1611 | 6 | 6¼ × 8¾ | .... | .... ... | .... |
| | 6-LD-1742 | Diesel | 1742 | 6 | 6½ × 8¾ | .... | .... ... | .... |

***Figures given under column "Rated H.P." refer to Cubic Inches Piston Displacement, and are not to be read as H.P.

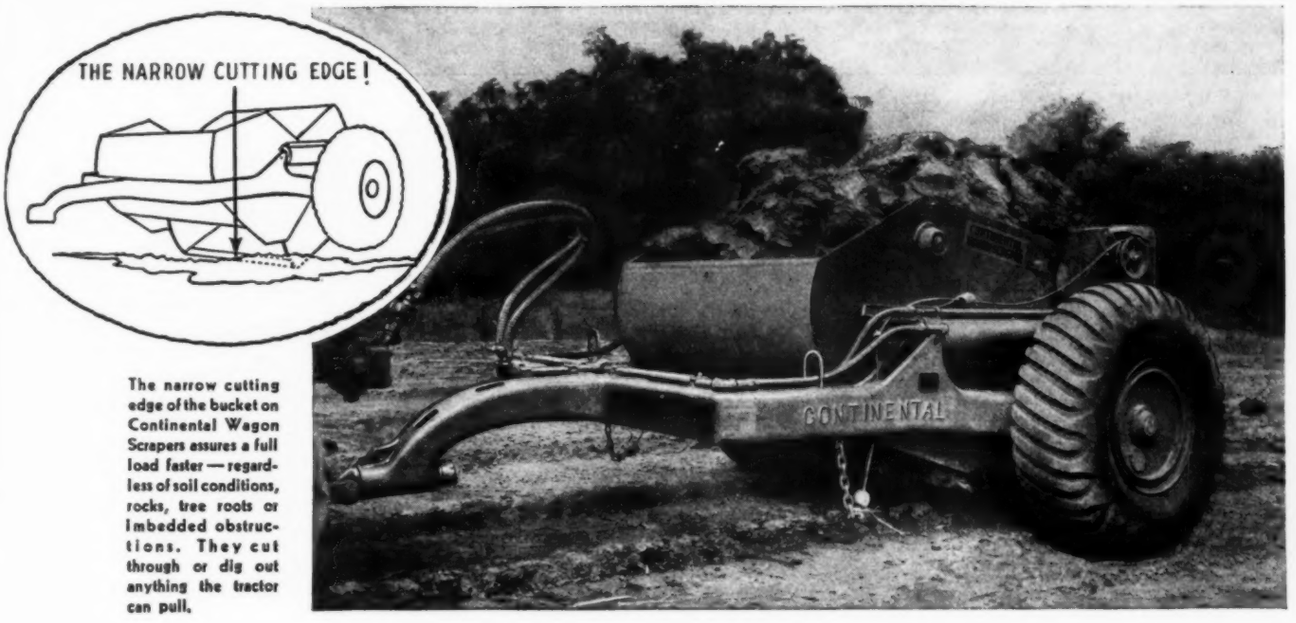
| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Caterpillar Tractor Co. | D4400 | Diesel | 44 | 4 | 4¼ × 5½ | 1400 | .... ... | 1975 |
| | D6600 | Diesel | 60 | 3 | 5¾ × 8 | 850 | .... ... | 3260 |
| | D7700 | Diesel | 63 | 4 | 5¼ × 8 | 850 | .... ... | 4040 |
| | D8800 | Diesel | 80 | 4 | 5⅝ × 8 | 850 | .... ... | 4090 |
| | D110000 | Diesel | 102 | 6 | 5¼ × 8 | 850 | .... ... | 4935 |
| | D13000 | Diesel | 125 | 6 | 5¾ × 8 | 850 | .... ... | 5035 |
| | D17000 | Diesel | 160 | 8(V type) | 5¼ × 8 | 850 | .... ... | 7600 |
| | 9500 G. | Gasoline | 96 | 4 | 7 × 8½ | 700 | .... ... | 3964 |

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | Net Weight |
|---|---|---|---|---|---|---|---|---|
| Climax Engineering Co. | G4A | Gasoline* | 19-38 | 4 | 4⅛ × 5¼ | 600/1500 | 177 ... | 1790 |
| | G4B | Gasoline* | 22-43 | 4 | 4⅜ × 5¼ | 600/1500 | 205 ... | 1790 |
| | G4C | Gasoline* | 23-45 | 4 | 4½ × 5¼ | 600/1500 | 217 ... | 1790 |
| | H4A | Gasoline* | 31-55 | 4 | 4¾ × 6¼ | 600/1200 | 275 ... | 2330 |
| | H4B | Gasoline* | 38-66 | 4 | 5¼ × 6¼ | 600/1200 | 340 ... | 2330 |
| | TU | Gasoline† | 43-65 | 4 | 5½ × 7 | 600/1200 | 378 ... | 3250 |
| | N4A | Gasoline* | 40-70 | 4 | 5¼ × 6½ | 600/1200 | 380 ... | 3060 |
| | N4B | Gasoline* | 50-88 | 4 | 5¾ × 6½ | 600/1200 | 463 ... | 3060 |
| | R4U | Gasoline† | 50-86 | 4 | 6 × 7 | 600/1200 | 475 ... | 4150 |
| | R4I | Gasoline* | 60-100 | 4 | 6 × 7 | 600/1200 | 550 ... | 4350 |
| | R6U | Gasoline† | 75-129 | 6 | 6 × 7 | 600/1200 | 700 ... | 4800 |
| | R6I | Gasoline* | 95-157 | 6 | 6 × 7 | 600/1200 | 820 ... | 5350 |
| | R8I | Gasoline* | 125-209 | 8 | 6 × 7 | 600/1200 | 1140 ... | 8000 |

*Gasoline or Natural Gas.
†Gasoline Only.

## CONTRACTORS' INDUSTRIAL ENGINES—POWER UNITS—Continued

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | | Net Weight |
|---|---|---|---|---|---|---|---|---|---|
| Le Roi Engine Co. | .... | Gasoline | 20 | 4 | 3⅜ × 4½ | 1200 | 83 | .... | 655* |
| | .... | Gasoline | 40 | 4 | 4 × 4 | 1800 | 83 | .... | 805* |
| | .... | Gasoline | 53 | 4 | 4½ × 5 | 1450 | 230 | .... | 1735* |
| | .... | Gasoline | 56 | 4 | 4½ × 6 | 1200 | 290 | .... | 1735* |
| | .... | Gasoline | 69 | 4 | 5 × 6 | 1200 | 340 | .... | 1735* |
| | .... | Gasoline | 63 | 4 | 5 × 7 | 1000 | 340 | .... | 2900* |
| | .... | Gasoline | 70 | 4 | 5¼ × 7 | 1000 | 670 | .... | 2925* |
| | .... | Gasoline | 77 | 4 | 5½ × 7 | 1000 | 670 | .... | 2950* |
| | .... | Gasoline | 89 | 4 | 6 × 7 | 1000 | 670 | .... | 3000* |
| | .... | Gasoline | 95 | 4 | 6¼ × 7 | 1000 | 580 | .... | 3050** |
| | .... | Gasoline | 103 | 4 | 6½ × 7 | 1000 | 1165 | .... | 3075** |
| | .... | Gasoline | 111 | 4 | 6¾ × 7 | 1000 | 1165 | .... | 3100** |
| *Weight complete Power Unit with Clutch. | .... | Gasoline | 94 | 6 | 5 × 7 | 1000 | 1385 | .... | 3200** |
| **Weight Engine only. | .... | Gasoline | 104 | 6 | 5¼ × 7 | 1000 | 1385 | .... | 3250** |
| | .... | Gasoline | 115 | 6 | 5½ × 7 | 1000 | 1165 | .... | 3300** |
| | .... | Gasoline | 133 | 6 | 6 × 7 | 1000 | 1165 | .... | 3350** |
| | .... | Gasoline | 144 | 6 | 6¼ × 7 | 1000 | 1385 | .... | 3900** |
| | .... | Gasoline | 156 | 6 | 6½ × 7 | 1000 | 1385 | .... | 3950** |
| | .... | Gasoline | 169 | 6 | 6¾ × 7 | 1000 | 1385 | .... | 4000** |
| | .... | Gasoline | 192 | 8 | 6¼ × 7 | 1000 | 1385 | .... | 5200** |
| | .... | Gasoline | 208 | 8 | 6½ × 7 | 1000 | 1385 | .... | 5250** |
| | .... | Gasoline | 224 | 8 | 6¾ × 7 | 1000 | 1385 | .... | 5300** |
| | .... | Gasoline | 309 | 12 | 6½ × 7 | 1000 | 2060 | .... | 6350** |
| | .... | Gasoline | 285 | 12 | 6¼ × 7 | 1000 | 2060 | .... | 6300** |
| | .... | Gasoline | 334 | 12 | 6¾ × 7 | 1000 | 2060 | .... | 6400** |
| Novo Engine Company | W25 | Gasoline* | 31 | 4 | 4 × 4 | 1300 | 128 | .... | 440 |
| | U-40 | Gasoline* | 40 | 4 | 4⅜ × 5 | 1200 | 180 | .... | 1000 |
| | E-60 | Gasoline* | 68 | 4 | 5¼ × 6½ | 1050 | 400 | .... | 1850 |
| | L-90 | Gasoline* | 102 | 6 | 5¼ × 6½ | 1050 | 550 | .... | 2900 |
| | *Either gasoline or distillate. | | | | | | | | |
| Waukesha Motor Co. | .... | Gasoline | 25.5 | 4 | 2¾ × 4 | 2600 | 63 | 1100 | 280 |
| | .... | Gasoline | 35 | 4 | 3¼ × 4 | 2600 | 87 | 1200 | 290 |
| | .... | Gasoline | 38 | 4 | 3⅝ × 4½ | 2200 | 122 | 950 | 385 |
| | .... | Gasoline | 55 | 4 | 3⅝ × 4¾ | 2200 | 91 | 1000 | .... |
| | .... | Gasoline | 48 | 4 | 4⅛ × 5¼ | 1500 | 175 | 1000 | 850 |
| | .... | Gasoline | 54 | 4 | 4½ × 5¼ | 1500 | 210 | 1000 | 925 |
| | .... | Gasoline | 58 | 4 | 4¾ × 6¼ | 1200 | 275 | 900 | 1575 |
| | .... | Gasoline | 68 | 4 | 5⅛ × 6¼ | 1200 | 320 | 900 | 1600 |
| | .... | Gasoline | 77 | 4 | 5½ × 6½ | 1200 | 395 | 700 | 1575 |
| | .... | Gasoline | 91.5 | 4 | 6 × 6½ | 1200 | 420 | 700 | 1600 |
| | .... | Gasoline | 97 | 4 | 6 × 6½ | 1200 | 482 | 650 | 1750 |
| | .... | Gasoline | 110 | 4 | 6½ × 7 | 1050 | 605 | 725 | 2400 |
| | .... | Gasoline | 124 | 4 | 6¾ × 8 | 1050 | 765 | 550 | 2750 |
| | .... | Gasoline | 155 | 4 | 7½ × 8 | 1050 | 925 | 650 | 3560 |
| | .... | Gasoline | 66 | 6 | 3⅜ × 4⅛ | 2800 | 155 | 1100 | 590 |
| | .... | Gasoline | 72 | 6 | 3½ × 4¼ | 2800 | 168 | 1200 | 675 |
| | .... | Gasoline | 82 | 6 | 3¾ × 4¼ | 2800 | 188 | 1050 | 690 |
| | .... | Gasoline | 78 | 6 | 4 × 4¾ | 2200 | 235 | 900 | 875 |
| | .... | Gasoline | 82 | 6 | 4⅛ × 4¾ | 2200 | 250 | 900 | 890 |
| | .... | Gasoline | 85 | 6 | 4¼ × 4¾ | 2000 | 265 | 900 | 920 |
| | .... | Gasoline | 107 | 6 | 4 × 4¾ | 2500 | 255 | 1300 | 1125 |
| | .... | Gasoline | 97 | 6 | 4⅜ × 5⅛ | 2000 | 300 | 700 | 1185 |
| | .... | Gasoline | 107 | 6 | 4⅝ × 5⅛ | 2000 | 370 | 750 | 1225 |
| | .... | Gasoline | 123 | 6 | 4⅝ × 5⅛ | 2300 | 330 | 1050 | 1425 |
| | .... | Gasoline | 128 | 6 | 5 × 5½ | 1800 | 465 | 800 | 2950 |
| | .... | Gasoline | 154 | 6 | 5½ × 5½ | 1800 | 548 | 800 | 2950 |
| | .... | Gasoline | 190 | 6 | 7 × 7 | 1125 | 1000 | 550 | 4975 |
| | .... | Gasoline | 240 | 6 | 7 × 8½ | 1050 | 1310 | 750 | 7500 |
| | .... | Gasoline | 290 | 6 | 7¾ × 8½ | 1050 | 1625 | 750 | 7500 |
| | .... | Gasoline | 335 | 6 | 8½ × 8½ | 1050 | 1850 | 700 | 7800 |
| | .... | Diesel | 41 | 4 | 3¾ × 4¾ | 2000 | 122 | 1400 | 715 |
| | .... | Diesel | 51 | 4 | 4½ × 5¼ | 1500 | 210 | 1100 | 915 |
| | .... | Diesel | 71 | 4 | 5 × 6½ | 1200 | 335 | 600 | 1875 |
| | .... | Diesel | 96 | 4 | 6 × 6½ | 1200 | 455 | 700 | 1900 |
| | .... | Diesel | 116 | 4 | 6½ × 8 | 1050 | 665 | 600 | 3200 |
| | .... | Diesel | 65 | 6 | 3¾ × 4¼ | 2500 | 172 | 1100 | 750 |
| | .... | Diesel | 162 | 6 | 6½ × 7 | 1125 | 900 | 500 | 4950 |
| | .... | Diesel | 185 | 6 | 7 × 7 | 1125 | 1030 | 525 | 4975 |
| | .... | Diesel | 335 | 6 | 8½ × 8½ | 1050 | 1820 | 550 | 7950 |
| | .... | Diesel | 80 | 6 | 3⅝ × 4½ | .... | .... | .... | .... |
| | .... | Diesel | 100 | 6 | 4⅜ × 5⅛ | 2200 | 275 | 1100 | 1675 |
| | .... | Diesel | 137 | 6 | 5 × 5½ | 2000 | 410 | 1100 | 2165 |
| Wisconsin Motors Corporation | SU | Gasoline | 35 | 4 | 4 × 5 | 1400 | 160 | .... | 1250 |
| | W | Gasoline | 39 | 4 | 4⅛ × 5 | 1400 | 180 | .... | 1250 |
| | X | Gasoline | 49 | 4 | 4½ × 5 | 1400 | 225 | .... | 1550 |
| | B-2 | Gasoline | 60 | 4 | 5¼ × 6½ | 1000 | 380 | .... | 2900 |
| | B-3 | Gasoline | 66 | 4 | 5½ × 6½ | 1000 | 420 | .... | 2900 |
| | K | Gasoline | 82 | 4 | 6 × 7 | 1000 | 535 | .... | 3400 |
| | K-2 | Gasoline | 86 | 4 | 6⅜ × 7 | 1000 | 585 | .... | 3400 |
| | GA-2 | Gasoline | 49 | 6 | 3¾ × 5 | 1600 | 210 | .... | 1750 |
| | L-2 | Gasoline | 56 | 6 | 3⅞ × 5 | 1600 | 235 | .... | 2000 |
| | L-3 | Gasoline | 62 | 6 | 4⅛ × 5 | 1600 | 260 | .... | 2000 |
| | L-4 | Gasoline | 66 | 6 | 4¼ × 5 | 1600 | 280 | .... | 2000 |
| | ZA-1 | Gasoline | 71 | 6 | 4½ × 5 | 1400 | 322 | .... | 2350 |
| | ZA-2 | Gasoline | 75 | 6 | 4⅝ × 5 | 1400 | 340 | .... | 2350 |
| | M-2 | Gasoline | 75 | 6 | 4¾ × 6 | 1200 | 435 | .... | 3300 |
| *All Gasoline Engines can be equipped to use manufactured or natural gas as fuel. | M-3 | Gasoline | 83 | 6 | 5 × 6 | 1200 | 475 | .... | 3300 |
| **In addition to the above oil burning units, oil burning equipment can be furnished for Model AD, AE, AF, AG, AH, and AC4 Engines. | M-4 | Gasoline | 90 | 6 | 5¼ × 6 | 1200 | 525 | .... | 3300 |
| | D-2 | Gasoline | 94 | 6 | 5¼ × 6½ | 1100 | 570 | .... | 4200 |
| | D-3 | Gasoline | 105 | 6 | 5½ × 6½ | 1100 | 640 | .... | 4200 |
| | D-4 | Gasoline | 116 | 6 | 5¾ × 6½ | 1100 | 700 | .... | 4200 |
| | E | Gasoline | 124 | 6 | 6 × 7 | 1000 | 810 | .... | 5300 |
| | E-2 | Gasoline | 141 | 6 | 6⅜ × 7 | 1000 | 910 | .... | 5300 |
| | E-2A | Gasoline | 169 | 6 | 6⅜ × 7 | 1200 | 950 | .... | 5300 |
| | BO-2 | Oil | 50 | 4 | 5¼ × 6½ | 1000 | ... | .... | 3050 |
| | BO-3 | Oil | 55 | 4 | 5½ × 6½ | 1000 | ... | .... | 3050 |
| | KO | Oil | 70 | 4 | 6 × 7 | 1000 | ... | .... | 3500 |
| | KO-2 | Oil | 75 | 4 | 6⅜ × 7 | 1000 | ... | .... | 3500 |
| | DO-2 | Oil | 78 | 6 | 5¼ × 6½ | 1100 | ... | .... | 4400 |
| | DO-3 | Oil | 86 | 6 | 5½ × 6½ | 1000 | ... | .... | 4400 |
| | DO-4A | Oil | 100 | 6 | 5¾ × 6½ | 1300 | ... | .... | 4400 |
| | EO | Oil | 105 | 6 | 6 × 7 | 1000 | ... | .... | 5500 |
| | EO-2 | Oil | 118 | 6 | 6⅜ × 7 | 1000 | ... | .... | 5500 |
| | EO-2A | Oil | 135 | 6 | 6⅜ × 7 | 1200 | ... | .... | 5500 |




The narrow cutting edge of the bucket on Continental Wagon Scrapers assures a full load faster — regardless of soil conditions, rocks, tree roots or imbedded obstructions. They cut through or dig out anything the tractor can pull.

# they out-dig all others!

*Continental Wagon Scrapers out-dig all others!* The reasons for this superior performance are simple — it's the fast digging, narrow cutting edge of the bucket — plus the rigid stability of Continental two-wheeled design.

The narrow, sharp cutting edge takes a bite the instant it touches the dirt — digs deep and forces a fast load — cuts through or digs out anything the tractor can pull — rocks, tree roots, and other imbedded obstructions. The depth of cut and bucket opening are adjustable. Two-way hydraulic controls allow for positive and accurate manipulation of the cutting edge regardless of soil conditions.

Continental Wagon Scrapers *Load, Haul, and Dump Faster!* They are strongest, yet lightest in weight, per yard of capacity. They backfill entirely over a fill, against walls or culverts, and are widely used for spreading and grading.

No matter what your dirt moving job may be — use a Continental Wagon Scraper to *get lowest cost per yard.* Made in 5, 7, and 10 yard sizes, mounted on rubber tired wheels, or crawlers for use with all sizes of crawler tractors.

May we give you details on how others have cut their dirt moving costs with Continental Wagon Scrapers one-half or more under other dirt moving methods?

Sold and serviced by Allis-Chalmers dealers everywhere.

CONTINENTAL ROLL & STEEL FOUNDRY COMPANY
*Tractor Equipment Division*
Railroad Ave. and 144th Street
East Chicago, Indiana

## 8 other Continental features!

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SUPERIOR ROAD MAKING MACHINERY

# CONTINENTAL WAGON SCRAPERS

## CONTRACTORS' INDUSTRIAL ENGINES—POWER UNITS—Continued

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | | Net Weight |
|---|---|---|---|---|---|---|---|---|---|
| Continental Motors Corporation..... | 33R | Gasoline | 115 | 6 | 4½ × 5¼ | 1800 | 344 | ... | 1471 |
| | 32R | Gasoline | 96.5 | 6 | 4⅜ × 4¾ | 1800 | 296 | ... | 1389 |
| | 31R | Gasoline | 86 | 6 | 4⅛ × 4¾ | 1800 | 264 | ... | 1356 |
| | E613 | Gasoline | 85.5 | 6 | 4¼ × 4½ | 1800 | 265 | ... | 975 |
| | E612 | Gasoline | 79.5 | 6 | 4⅛ × 4½ | 1800 | 251 | ... | 955 |
| | E611 | Gasoline | 69 | 6 | 3⅞ × 4½ | 1800 | 215 | ... | 935 |
| | E610 | Gasoline | 61 | 6 | 3⅞ × 4½ | 1800 | 192 | ... | 915 |
| | A244 | Gasoline | 56 | 6 | 3⅞ × 4⅜ | 1800 | 169 | ... | 548 |
| | F218 | Gasoline | 52 | 6 | 3¼ × 4⅜ | 1800 | 158 | ... | 510 |
| | F199 | Gasoline | 47 | 6 | 3¼ × 4 | 1800 | 144 | ... | 483 |
| | F170 | Gasoline | 40 | 6 | 3 × 4 | 1800 | 118 | ... | 441 |
| | D6202 | Oil | 40 | 6 | 3⅛ × 4⅜ | 1800 | 128 | ... | ... |
| | C143 | Gasoline | 35 | 4 | 3⅜ × 4 | 1800 | 104 | ... | 375 |
| | Y91 | Gasoline | 21 | 4 | 2⅞ × 3½ | 1800 | 62 | ... | 293 |
| | Y69 | Gasoline | 15.5 | 4 | 2½ × 3½ | 1800 | 47 | ... | 286 |
| Covic Diesel Engine Corporation..... | .... | Diesel | 18-20 | 2 | 3 9/64 × 3 11/16 | 800* | 47 | 800 | 280 |

*May be operated at speeds 500 to 3000.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cummins Engine Company..... | HI4 | Diesel | 55 | 4 | 4⅞ × 6 | 1200 | 375 | 800 | 1500 |
| | HI6 | Diesel | 85 | 6 | 4⅞ × 6 | 1200 | 425 | 800 | 1900 |
| | K4 | Diesel | 100 | 4 | 6¾ × 9 | 700 | 860 | 500 | 5400 |
| | K6 | Diesel | 165 | 6 | 6¾ × 9 | 800 | 1260 | 550 | 7075 |
| | KO4 | Diesel | 105 | 4 | 7 × 9 | 700 | 900 | 525 | 5400 |
| | KO6 | Diesel | 180 | 6 | 7 × 9 | 800 | 1350 | 550 | 7075 |
| | L5 | Diesel | 85 | 3 | 7 × 10 | 700 | 740 | 500 | 4645 |
| | L4 | Diesel | 115 | 4 | 7 × 10 | 700 | 980 | 525 | 5475 |
| | L6 | Diesel | 200 | 6 | 7 × 10 | 800 | 1500 | 550 | 7175 |
| Fairbanks Morse & Co..... | .... | Gasoline* | 22.8 | 4 | 3½ × 4½ | 1800 | ... | .... | 925 |
| | .... | Gasoline* | 27.5 | 4 | 4 × 4½ | 1800 | ... | .... | 950 |
| | .... | Gasoline* | 30.1 | 6 | 3¼ × 4⅛ | .... | ... | .... | 1190 |
| | .... | Gasoline* | 36.0 | 6 | 3⅝ × 4¼ | .... | ... | .... | 1240 |
| | .... | Gasoline* | 38.8 | 6 | 3¾ × 4¼ | .... | ... | .... | 1280 |
| | 36A4¼ | Diesel | 26 | 2 | 4¼ × 6 | 1200 | 114 | 1200 | 1232 |
| | 36A4¼ | Diesel | 39 | 3 | 4¼ × 6 | 1200 | 171 | 1200 | 1528 |
| | 36A4¼ | Diesel | 52 | 4 | 4¼ × 6 | 1200 | 228 | 1200 | 2253 |
| | 36A4¼ | Diesel | 78 | 6 | 4¼ × 6 | 1200 | 341 | 1200 | 2878 |
| | 36A5½ | Diesel | 100 | 4 | 5½ × 7½ | 1200 | 438 | 1200 | 3028 |
| | 36A5½ | Diesel | 150 | 6 | 5½ × 7½ | 1200 | 657 | 1200 | 4290 |
| | 36A5½ | Diesel | 200 | Straight 8 | 5½ × 7½ | 1200 | 875 | 1200 | 5535 |
| Ford Motor Company..... | .... | Gasoline* | 85 | 8(V type) | 3.062 × 3.75 | 3800 | 146 | 1750 | 654 |

*Attachments for using natural or manufactured gas available.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hercules Motors Corporation***..... | ZXA | Gasoline | 58.8 cu. in. | 4 | 2½ × 3 | .... | ... | ... | .... |
| | ZXB | Gasoline | 64.9 | 4 | 2⅝ × 3 | .... | ... | ... | .... |
| | IX | Gasoline | 78.5 | 4 | 2½ × 4 | .... | ... | ... | .... |
| | IXA | Gasoline | 113 | 4 | 3 × 4 | .... | ... | ... | .... |
| | IXB | Gasoline | 133 | 4 | 3¼ × 4 | .... | ... | ... | .... |
| | OOA | Gasoline | 173.2 | 4 | 3½ × 4½ | .... | ... | ... | .... |
| | OOB | Gasoline | 198.8 | 4 | 3¾ × 4½ | .... | ... | ... | .... |
| | OOC | Gasoline | 226.2 | 4 | 4 × 4½ | .... | ... | ... | .... |
| | OX | Gasoline | 251.3 | 4 | 4 × 5 | .... | ... | ... | .... |
| | OXC | Gasoline | 283.5 | 4 | 4¼ × 5 | .... | ... | ... | .... |
| | K | Gasoline | 326.3 | 4 | 4¼ × 5¾ | .... | ... | ... | .... |
| | L | Gasoline | 365.8 | 4 | 4½ × 5¾ | .... | ... | ... | .... |
| | G | Gasoline | 407.6 | 4 | 4¾ × 5¾ | .... | ... | ... | .... |
| | E | Gasoline | 451.4 | 4 | 5 × 5¾ | .... | ... | ... | .... |
| | TX | Gasoline | 665 | 4 | 5½ × 7 | .... | ... | .... | .... |
| | TXA | Gasoline | 792 | 4 | 6 × 7 | .... | ... | ... | .... |
| | TXO | Gasoline | 893 | 4 | 6⅜ × 7 | .... | ... | ... | .... |
| | QXA | Gasoline | 190 | 6 | 3⅛ × 4⅛ | .... | ... | ... | .... |
| | QXB | Gasoline | 205 | 6 | 3¼ × 4⅛ | .... | ... | ... | .... |
| | JXA | Gasoline | 228 | 6 | 3⅜ × 4¼ | .... | ... | ... | .... |
| | JXB | Gasoline | 263 | 6 | 3⅝ × 4¼ | .... | ... | ... | .... |
| | JXC | Gasoline | 282 | 6 | 3¾ × 4¼ | .... | ... | ... | .... |
| | JXD | Gasoline | 320 | 6 | 4 × 4¼ | .... | ... | ... | .... |
| | WXC | Gasoline | 339 | 6 | 4 × 4½ | .... | ... | ... | .... |
| | WXC2 | Gasoline | 260.8 | 6 | 4⅛ × 4½ | .... | ... | ... | .... |
| | WXC3 | Gasoline | 383 | 6 | 4¼ × 4½ | .... | ... | ... | .... |
| | YXC | Gasoline | 428.4 | 6 | 4⅜ × 4¾ | .... | ... | ... | .... |
| | YXC2 | Gasoline | 453 | 6 | 4½ × 4¾ | .... | ... | ... | .... |
| | YXC3 | Gasoline | 478.8 | 6 | 4⅝ × 4¾ | .... | ... | ... | .... |
| | RXB | Gasoline | 501 | 6 | 4½ × 5¼ | .... | ... | .. | .... |
| | RXC | Gasoline | 529 | 6 | 4⅝ × 5¼ | .... | ... | ... | .... |
| | HXB | Gasoline | 707 | 6 | 5 × 6 | .... | ... | ... | .... |
| | HXC | Gasoline | 779 | 6 | 5¼ × 6 | .... | ... | ... | .... |
| | HXD | Gasoline | 855 | 6 | 5½ × 6 | .... | ... | ... | .... |
| | HXE | Gasoline | 935 | 6 | 5⅝ × 6 | .... | ... | ... | .... |
| | DJXB | Diesel | 260 | 6 | 3½ × 4½ | .... | ... | ... | .... |
| | DJXC | Diesel | 298 | 6 | 3¾ × 4½ | .... | ... | ... | .... |
| | DRXB | Diesel | 474 | 6 | 4⅞ × 5¼ | .... | ... | ... | .... |
| | DHXB | Diesel | 707 | 6 | 5 × 6 | .... | ... | ... | .... |

***Figures given under column "Rated H.P." refer to Cubic Inches Piston Displacement and are not to be read as H.P.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| International Harvester Company..... | P-12 | Gasoline* | 18** | 4 | 3 × 4 | 2000 | 195 | .... | 850 |
| | 200 | Gasoline* | 26.8 | 4 | 4¼ × 5 | 1000 | 531 | .... | 1570 |
| | P-30 | Gasoline* | 32 | 4 | 4¼ × 5 | 1150 | 531 | .... | 1695 |
| | 300 | Gasoline* | 37.6 | 4 | 4¾ × 6 | 1050 | 722 | .... | 2110 |
| | P-40 | No. 1 Distillate | 42.8 | 6 | 3¾ × 4½ | 1800 | 722 | .... | 2010 |
| | PA-40 | Gasoline | 47.6 | 6 | 3⅝ × 4½ | 1800 | 722 | .... | 2010 |
| | PA-50 | Gasoline | 53.2 | 6 | 3¾ × 4½ | 1800 | 722 | .... | 2010 |
| | PD-40 | Diesel | 50 | 4 | 4¾ × 6½ | 1250 | 722 | .... | 2785 |
| | PD-80 | Diesel | 80 | 6 | 4¾ × 6½ | 1400 | 785 | .... | 3750 |
| | PA-100 | Gasoline | 88 | 6 | 5 × 5½ | 1400 | 785 | .... | 3335 |

*Equipment for using kerosene or distillate available. Gas burning equipment available for all models except PD-40 and PD-80.

**Continuous Horsepower is 80% of maximum quoted for all models.

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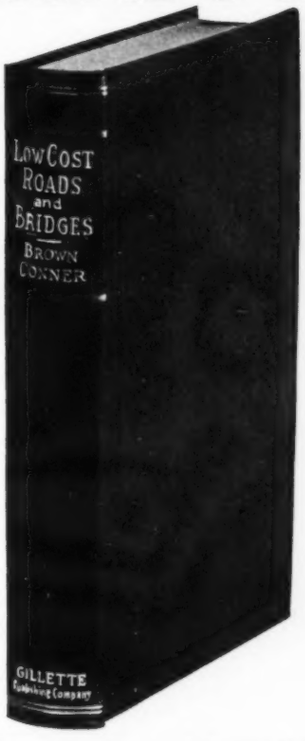


by

V. J. BROWN, C. E.
*Publishing Director, Roads and Streets, Asso. Mem. Am. Soc. C. E., Mem. Western Soc. Eng., Mem. Am. Road Bldrs. Assn.*

C. N. CONNER, B. S. in C. E.,
*Chairman, Department of Design, Highway Research Board. Formerly Engineering Executive, Am. Road Builders Assoc. Mem. Am. Soc. C. E.*

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In a work of this kind, one would not expect to find any discussion of the more expensive types of surfacing —sheet asphalt, brick, stone block, etc.—nor does it appear. The treatment of the lower types, however, is entirely adequate. The authors have not hesitated to enlist the cooperation of a number of specialists, which adds much to the value of their book.

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**The authors of this volume were far-sighted enough to know that for future construction the economics of highway types would play an increasingly important part in improvement programs. They have, therefore, thoroughly discussed this phase of highway planning.**

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R&S-3-37

| Manufacturer | Model | Fuel Used | Rated H.P. | No. Cyl. | Bore and Stroke | R.P.M. | Torque Pounds—Feet | | Net Weight |
|---|---|---|---|---|---|---|---|---|---|
| Worthington Pump & Machy. Corp.... | R-2 | Diesel Oil | 50 | 2 | 8 ×10½ | 514 | ... | ... | 7700 |
| | BB-2 | Diesel Oil | 60 | 2 | 8 ×10½ | 600 | ... | ... | 7900 |
| | B-3 | Diesel Oil | 75 | 3 | 8 ×10½ | 514 | ... | ... | 9600 |
| | BB-3 | Diesel Oil | 90 | 3 | 8 ×10½ | 600 | ... | ... | 9800 |
| | B-4 | Diesel Oil | 100 | 4 | 8 ×10½ | 514 | ... | ... | 10600 |
| | BB-4 | Diesel Oil | 120 | 4 | 8 ×10½ | 600 | ... | ... | 11000 |
| | B-5 | Diesel Oil | 125 | 5 | 8 ×10½ | 514 | ... | ... | 12000 |
| | BB-5 | Diesel Oil | 150 | 5 | 8 ×10½ | 600 | ... | ... | 13000 |
| | B-6 | Diesel Oil | 150 | 6 | 8 ×10½ | 514 | ... | ... | 13750 |
| | BB-6 | Diesel Oil | 180 | 6 | 8 ×10½ | 600 | ... | ... | 15000 |
| | C-3 | Diesel Oil | 150 | 3 | 10¾ ×14½ | 400 | ... | ... | 20250 |
| | C-4 | Diesel Oil | 200 | 4 | 10¾ ×14½ | 400 | ... | ... | 23250 |
| | C-5 | Diesel Oil | 250 | 5 | 10¾ ×14½ | 400 | ... | ... | 27250 |
| | C-6 | Diesel Oil | 300 | 6 | 10¾ ×14½ | 400 | ... | ... | 31250 |

*Engine Tables Will Be Continued Next Month*

## Causes of Road Accidents in England

According to the London Daily Telegraph of January 14, an analysis of the contributory causes of 760 accidents showed that:

246 were due to slippery road surface or worn paving blocks;
266 to blind corners and bad visibility;
64 to surface in bad repair;
60 to defective shape of carriageway;
66 to street car tracks, pavings, etc.;
46 to difficult bends.

In London, 438 cases were investigated, in 30 of which the road conditions were not contributory. Of the others, the alleged contributory causes included:

Bad road surfaces, 51;
Dangerous corners, 39;
Skidding, 28;
Slipping on pedestrian crossing studs, 20;
Defective lighting, 47;
Collision with obstacles on footway, 70.

▼

## Rules of $50,000,000 Grade Crossing Safety Program Announced

The Secretary of Agriculture on Feb. 12 announced the terms under which the states can share in the $50,000,000 Federal fund for continuing through the next fiscal year on a permanent basis the program of eliminating hazards at railroad grade crossings. The funds, authorized by the act of Congress of June 16, 1936, were apportioned among the various States, the District of Columbia, Hawaii and Puerto Rico by the Secretary on Dec. 29, 1936, and become available for expenditure on July 1. The apportionment to the various states is given in the January issue of ROADS AND STREETS. The Bureau of Public Roads will administer the funds in cooperation with State highway departments.

These new funds are in addition to the initial appropriation of $200,000,000 of emergency funds under which grade crossing elimination work is now under way and will be expended in much the same way.

Five types of grade crossing elimination and protection developments are eligible: (1) Separation of grades at crossings; (2) installation of protective devices at grade crossings; (3) reconstruction of existing grade separation structures; (4) relocation of highways to eliminate grade crossings; and (5) relocation of railroads to eliminate grade crossings. The funds are available to pay the cost of construction exclusive of cost of rights of way or property damage, and can be spent either on rural highways or on city streets.

To insure a fair distribution of benefits among the railroads in each state, the regulations require that improvements shall be divided among the various railroads so that the amount expended on each shall be approximately in proportion to its mileage. On each railroad, crossings of the greatest hazard to traffic are to be selected for elimination or protection. Intiative in selecting projects for improvement rests with the state authorities who will prepare programs, and submit them to the Bureau of Public Roads for approval.

Where legal authority exists in a state for the physical closure of railroad grade crossings and where, by the construction of a grade separation structure with adequate approaches the use of an existing grade crossing structure is rendered unnecessary for the convenience of the general public, the regulations require that approval of a project for the construction of a grade separation structure shall be contingent upon prior provision for the physical closure of such grade crossing or crossings after completion of the new structure. Any lateral connection necessary to accomplish the physical closure of such existing grade crossings may be included as part of a project and paid for with grade crossing funds.

▼

## Flood Damages to Indiana Roads Amount to $250,000

Surveys by the Indiana State Highway Commission show that repairs of flood damage on the state highway system will cost $250,000. The state highway system was fortunate in escaping more damage during the flood period when it is considered that approximately 325 miles of highways were submerged for days at a time. Most of this mileage was along the Ohio River and the lower parts of the White and Wabash Rivers, where flood waters reached record-breaking levels. At one time it was estimated that normal traffic was affected on 1,300 miles of state highways in the southern part of the state.

The largest single item of damage on the state highway system was the washing out of a bridge and part of a fill on Road 50 west of Brownstown. Cost of replacement here is estimated at $50,000. The washing of fills and damage to shoulders will cost approximately $35,000; slides which took away part of the highway or covered the traveling surface cost nearly $45,000 and damage to highway surfaces has been placed at more than $11,000.

Highway engineers making a thorough survey of the areas affected by flood waters have recommended the construction of bridges on Road 41, near Hazleton, to take care of overflow from White River and additional protection of fills by more extensive use of rip-rap. The work recommended would cost approximately $250,000.

# *SPEED versus* SAFETY FOR HIGHWAY TRAFFIC

By HARRY TUCKER

*Professor Highway Engineering, North Carolina State College of Agriculture and Engineering of the University of North Carolina, Raleigh, N. C.*

HIGHWAY accidents have increased continuously, except for 1932, since the introduction of motor vehicles. The public had been more or less indifferent until the latter part of 1935. Beginning with the publication of several forceful articles describing the seriousness of highway accidents, the public has begun to realize that some radical steps must be taken if the increase in automobile accidents is to be materially halted. Many proposals have been made, some of them practical, others of little value. And there has been much discussion of the relation of speed to the number and seriousness of highway accidents.

It is an accepted fact that average speeds on highways have increased considerably during recent years. At the same time, the introduction of all-steel bodies, safety glass, and more efficient brakes has reduced the seriousness of the accidents that actually happen. In spite of the improvements on roads and the vehicles themselves, however, the number of persons killed each year on the highways has increased. The thoughtful student of accident statistics, therefore, questions if speed might not be an important element in the highway accident situation.

The writer is of the opinion that fast driving has a very marked influence on the number of fatal motor vehicle accidents. It is believed that motor vehicle manufacturers, road builders and a large proportion of the general public fail to realize the influence of excessive speeds on traffic accidents. If they did, it is doubtful if so much emphasis would be placed on potential speed in the advertisements of motor vehicles. Nor would such news items as "Builds super-highway for speeds of 100 miles per hour" be hailed with such popular acclaim. Instead of glorifying speed, it is believed that both motor manufacturer and highway builders should utilize every opportunity to emphasize that travel over almost perfect highways in well-designed vehicles at high speeds *is never safe.* And the greatest responsibility in this respect falls upon the highway engineers. It is not alone their duty to build the finest highways possible, but to use their influence to the end that the roads which they have built shall be used in a safe manner.

Many motorists advocate high speeds under the following conditions: Over well-designed highways, with a vehicle incorporating all safety features and with experienced drivers at the wheels. If these are the conditions for safe travel at high speeds, then it is significant that over 65 per cent of traffic fatalities occur on straight well-paved roads, with experienced drivers operating mechanically perfect vehicles. There must be some other important factor to be considered. Accident statistics show clearly that fast driving is the one factor that, more than all others, is responsible for traffic fatalities, when other conditions are favorable.

The accident statistics which follow are for highway fatalities. It will be granted that speed does not play as important a part in numerous minor accidents as it does in the fatal accidents. But fatalities and severe personal injuries should be prevented first; then it is proper to consider the other great class of accidents involving property damage and minor injuries. Likewise, the discussion which follows refers particularly to high speed on rural highways.

## Accident Statistics

Highway fatalities for the last five years, with the reported percentage due to "exceeding speed limit," are as follows:

| Year | Fatalities Total | Exceeding Per Cent Speed Limit |
|---|---|---|
| 1930 | 32,929 | 30.9 |
| 1931 | 33,675 | 25.7 |
| 1932 | 29,451 | 35.3 |
| 1933 | 31,363 | 32.8 |
| 1934 | 36,000 | 31.0 |
| 1935 | 37,000 | 30.7 |

According to the official records, it appears that one out of every three highway fatalities is due to "exceeding speed limit." But many investigators believe that these percentages are entirely too low. There are other violations listed, such as "Reckless Driving," where speed is a very vital factor. Then, too, the "sky is the limit" as far as speed is concerned in many of the States, and when a fatality occurs, even though the driver was exceeding a safe speed, the violation is listed under some other heading. In North Carolina, for example, "exceeding the speed limit" is officially recorded as the driver's violation in only 19.3 per cent of traffic fatalities over a period of seven years. In Massachusetts, on the other hand, 47.6 per cent of all traffic fatalities in 1934 were officially recorded as due to "speed too fast for conditions." The variations from State to State given in the records for this violation are probably due to different systems of reporting violations. But students of accident statistics are in fairly close agreement that about 60 per cent of all highway fatalities are due to fast driving. Is not this a tremendous sacrifice to the god, Speed?

The influence of speed on highway fatalities is well illustrated by the increase in motor vehicle accidents in

rural areas and on curves. The figures in percentages for fatal accidents only are as follows:

| Year | Rural Accidents Per Cent | On Curves Per Cent |
|---|---|---|
| 1924 | 52.0 | .... |
| 1928 | 56.6 | .... |
| 1930 | 60.0 | 7.8 |
| 1931 | 61.8 | 7.2 |
| 1932 | 62.4 | 8.1 |
| 1933 | 62.9 | 8.1 |
| 1934 | 64.0 | 11.1 |
| 1935 | 68.0 | 11.0 |

Thus, in spite of all the improvements made in recent years in motor vehicles, to make them safer, and with the billions of dollars spent on rural roads, actually more people are being killed on these roads, than at any time before such improvements were effected. In fact, it is probable that the improvements of highways "inviting the motorist to travel at high speeds," has actually resulted in greater highway fatalities. The State of Virginia is a good illustration of this statement. It is well known that this State has made tremendous improvements in its highway system in recent years, particularly in eliminating curves, widening pavements, and reducing grades. Since travel has probably increased, there is also given below the highway fatalities on the basis of gasoline consumption.

DATA FOR VIRGINIA

| Year | Deaths | Gasoline Consumption in Gallons | Death Rate Per 10,000,000 Gallons of Gasoline |
|---|---|---|---|
| 1929 | 475 | 208,304,000 | 22.8 |
| 1930 | 567 | 228,453,000 | 24.8 |
| 1931 | 698 | 244,151,000 | 28.6 |
| 1932 | 610 | 229,480,000 | 26.6 |
| 1933 | 612 | 233,439,000 | 26.2 |
| 1934 | 716 | 264,102,000 | 27.1 |
| 1935 | 856 | ..... | 26.0 |

And in considering the above figures it must be remembered that Virginia has a Highway Patrol, a Driver's License Law, a Motor Vehicle Inspection Act, and has a reputation for strict enforcement of the provisions of these laws. There are other States where the accident records have been similar to those in Virginia.

Since statistics in Virginia have been cited, it might be of interest to note that the new Suffolk-Portsmouth three-lane road has become a scene of numerous fatal accidents. The reports of these fatalities, and especially the editorial comments, seem to indicate that the 3-lane super-highway, has been turned into a speed-way and that speed is the primary cause of these fatalities. It is evident, therefore, that the consequences of speeding are just as serious on 3-lane and 4-lane super-highways, if not more so, than on the narrow roadway of ten years ago.

## The Effect of Speed

Do motorists operate their cars at the high speeds on rural highways? Unfortunately there are not sufficient data available to warrant definite statements. Records of speed made in New Jersey and Massachusetts seem to indicate that, on State Routes, traffic averages close to 45 miles per hour, with some cars exceeding 80 miles per hour. In strictly rural states, it is believed that the average speed on many state highways will be close to 50 miles per hour. If this is the average, it is clear that many vehicles are traveling at 80 miles per hour or better.

A highway cannot be made safe for travel at these high maximum speeds. If they were built perfectly straight, with low grades, and sufficiently wide so that each vehicle would have the exclusive use of a lane, they would still not be safe for travel at high speeds. This is a broad statement, but it is believed that it is justified by accident statistics. Thus, let us examine the following figures covering fatal motor vehicle accidents:

| Year | Non-Collision Accidents Per Cent | Between Intersections Per Cent |
|---|---|---|
| 1929 | 10.82 | (*) |
| 1930 | (*) | 21.9 |
| 1931 | 12.20 | 23.1 |
| 1932 | (*) | 25.6 |
| 1933 | 11.94 | 26.7 |
| 1934 | 12.60 | 23.2 |
| 1935 | 11.90 | 23.5 |

*Figures not available to writer.

It is seen that about one out of every eight fatal accidents are non-collision accidents. But practically 45 per cent of all fatal traffic accidents involve pedestrians, and are necessarily collision accidents. Therefore, nearly one out of every four fatal traffic accidents, not involving pedestrians, are non-collision accidents. The second set of figures show that one out of every four traffic fatalities occur between intersections; that is, on those sections of road where there are the fewest hazards. Thus, even on perfect highways, traffic accidents must necessarily occur due to carelessness, inattention, and errors of judgment, all on the part of the drivers. And to this group of accidents caused by the actions of the drivers must be added the 10 per cent of fatal accidents directly attributed to mechanical defects in the vehicles.

A little thought will show that the emergencies resulting in the group of accidents listed in the foregoing paragraph are not only, frequently, produced by speed, but when accidents occur under such conditions, the high speeds at which the vehicles were traveling were responsible for fatalities instead of injuries. This fact is understood when it is remembered that the effect of a blow delivered by a vehicle varies as the square of the speed. At 80 miles per hour the damage done by a vehicle colliding with a fixed object would be four times as great as if the vehicle were going at 40 miles per hour.

If one wishes to note the effect of speed in the event of a highway accident, it will only be necessary to visit any garage, in any section of the country, that specializes in rebuilding wrecked motor vehicles. Here one will have visual evidences of the tremendous forces which have twisted and broken those strong vehicles into fastastic shapes. When viewing the results of these accidents, one wonders how it was possible for any passenger to emerge alive from such a wreck.

Incidentally, it should be pointed out that the most dangerous results of speed are not direct but indirect. That is, one who travels habitually at excessive speeds on rural roads may have a serious accident at some other location when traveling at a relatively moderate pace. The reason seems to be that the driver's mind is tuned to fast travel and he becomes impatient at the necessary delay which is encountered in slower driving.

## Highway Design

It is not possible in a short article of this kind to discuss in detail the design of a highway so that it might be traveled at unlimited speed. It has been pointed out that even wide, straight roads are not free from traffic fatalities. But let it be assumed that all that is necessary in order to prevent motor vehicle accidents, as far as road design is concerned, is to build highways with slight curves, properly super-elevated for maximum speed, with wide lanes, low grades, and non-skid (?)

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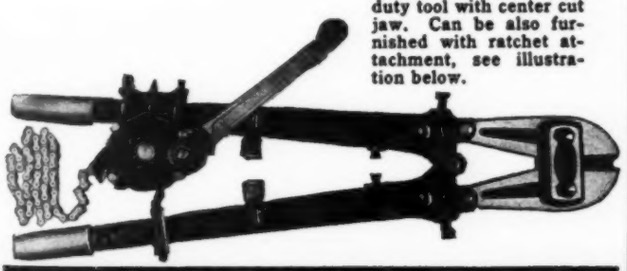

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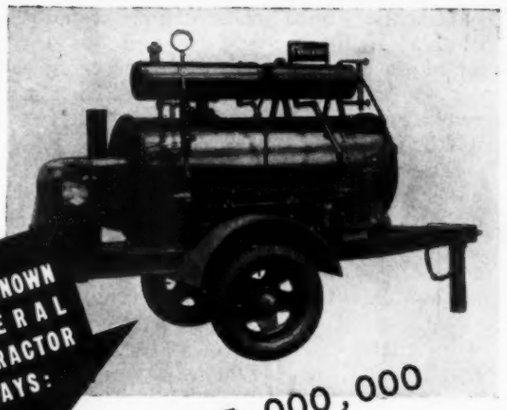

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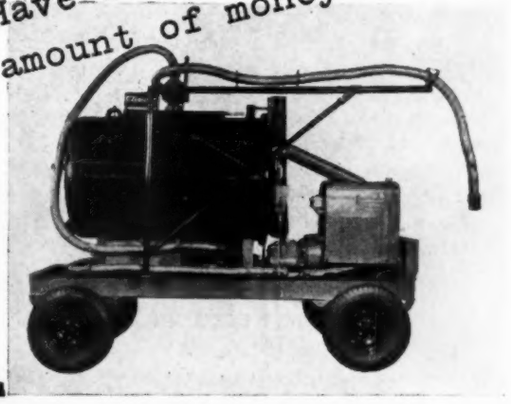

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pavements. Such construction would be extremely costly. If these roads are designed for a maximum speed of 80 miles per hour, the minimum radius of curves would be 4,270 ft., based on a maximum permissible super-elevation of one-tenth foot per foot of width.

The necessity of building roads with low curvature, either wider or with a greater number of traffic lanes, of low grades and with skid-proof surfaces, to accommodate high speed traffic, would greatly increase the cost of highway construction for a particular route. The additional cost certainly cannot be justified economically, when there is such a small percentage of traffic which will ever need to travel at such high speeds. It must be remembered that high speed does not increase the capacity of a traffic lane. As a matter of fact, it seems that maximum traffic capacity is attained with a uniform speed of about 20 to 25 miles per hour.

There would seem to be some justification for building special service or express roads, particularly designed for high speed traffic. In this case, the nature of the services justifies the design. But it is clear; that, if accident statistics may be taken at face value, vehicles should be allowed to operate over them only under the most rigorous regulations. Their operation should be supervised with all the minute care and detail exercised in operating a trunk-line railway.

In this age of speed, it might be well to point out that fast travel on a railroad and in the air may be indulged in quite legitimately, while on the highways it is dangerous. On a railroad, the track is designed for maximum speed, the train is rigorously inspected at frequent intervals and places, the operator is experienced, sane and dependable, and the direction of travel is fixed. None of these conditions exists for highway traffic. Is it any wonder, then, that fatalities on the highways continue to mount to a dreadful total, while deaths on railroads have declined steadily. And, in the air, of course, safety lies in speed. And when accidents occur, either on the railroads, or in the air, there is an investigation by an official body to find the cause and fix the blame. And this, of necessity, makes for safer travel by air and rail.

## The Personal Element

There is still the claim that speed on the highways is legitimate and safe, if drivers are carefully selected and rigorously supervised. This claim is partly true—to the extent that travel at high speeds would be *safer* than at present. But if these conditions were met, a great many who now drive motor vehicles would not be able to secure a driver's license, and fairly large armies of patrolmen would be required to supervise traffic. Do the motor vehicle manufacturers and highway builders desire to limit the use of vehicles, for one thing, and to fasten upon the people an additional burden of financing the armies of enforcement officers, for another thing, in order to permit excessive speeds by a limited number of professional drivers? Why not return to sanity, and urge a reduction in maximum speed? Why not remove the incentive to reckless driving, which is the "tremendous" potential speed of the vehicle?

## The Control of Speed

One needs only to read the newspaper editorials of recent months to find a distinct trend towards a demand for lower maximum speeds on the highways. This will, undoubtedly, be one of the major topics for debate in forthcoming sessions of State Legislatures. It is believed that engineers should anticipate this popular reaction to speed, and work out some sensible method by which speed on the highways can be controlled. The method of legislative fiat has been tried and found wanting. The use of governors on motor vehicles will be the method most often discussed. A tax on speed, suggested by Judge Stoeckel, is, in the writer's opinion, both practical and effective, for it will control speed at the source—the motor manufacturer.

Will any of these methods help to make highway travel safer? Unfortunately, there does not seem to be any statistics available which can be used either to prove or disprove that speed regulation will be helpful. The Indiana Highway Commission, however, has equipped some of its motor vehicles used by employes for official purposes with governors limiting the speed to 60 miles per hour. In an article in "Better Roads," June 1935 issue, James D. Adams, Chairman, writes: "The experience of our department discloses that with governors on our cars the property damage and the percentage of wrecks are greatly reduced as compared with the period when the cars were operating with no [speed] restrictions or control."

## Making Roads Safer

It is well to point out that there are elements in the design of highways, other than those influenced by speed, which have a marked effect on highway fatalities, and to which highway engineers might give more attention. The most important of these are intersections, shoulders, sidewalks and lighting. Much has been accomplished in decreasing the hazards of highway travel by separation of grades for railroad-highways and for intersecting highways. A great deal remains to be done, especially in making highway intersections safer where it is impracticable, or money is not available, for separating the grades.

A study of traffic accidents will reveal the large percentage of fatalities caused by vehicles being forced off the pavement and onto the shoulders. The bad condition of the shoulder frequently causes the driver to lose control of his vehicle. Shoulders should be wide enough and of such material, that they may be used with safety in an emergency. And connected somewhat with the question of shoulders is that of sidewalks for pedestrians, since both are elements of the cross-section. At the present time twenty per cent of all highway fatalities involve pedestrians on rural roads. Here, then, is a problem that should demand the immediate attention of highway engineers. The pedestrian has the right to use the roads, and, until suitable walkways are provided, his presence on the pavement will constitute an important traffic hazard.

On the basis of traffic, more accidents occur at night than during the day. The lighting of highways will, therefore, afford a means, not only of increasing the capacity of highways, but of bringing about a decrease in accidents.

To summarize: (1) It is believed that speed on rural highways in excess of 50 or possibly 60 miles per hour is inherently dangerous when made available for 50,000,000 or more drivers operating 26,000,000 motor vehicles. (2) That it is neither practical nor economical to design highways for excessive speeds, except for special service roads where traffic will be rigidly controlled. (3) That there are several elements in the design of highways, and affecting their safe use, to which highway engineers might devote time, thought, and money, rather than designing highways for excessive speed. (4) And, finally, engineers should use their positions and influence to point out the dangers of high-speed travel on any of the roads in any type of motor vehicle.

# OBSERVATIONS BY THE WAY

**By A. PUDDLE JUMPER**

¶ One of the perfect nuisances on highways are the big trucks and tractor-trailer outfits that have no mudguards down over *all* of the wheels. Those truck wheels spatter windshields when automobiles pass them on wet pavements so that it is nearly impossible to see. Let's correct this by requiring mud-guards on those big outfits.

• •

¶ You've never really attended a convention banquet until you've been to a National Paving Brick Ass'n Convention with Bill Moseley (Poston-Springfield Brick Co., Ill.) as toastmaster. He certainly helped to keep the manufacturers' minds off their problems for a while at their 31st annual convention in Detroit recently.

• •

¶ A few miles north of Montgomery, Alabama, the state highway department engineers showed me a low cost road in the secondary system from which they expect excellent results. It has a 6 in. stabilized base covered by a ¼ in. bituminous surface treatment. Hot bitumen was spread by a distributor (a spritzer I'd like to call it), and gravel or slag rolled into the hot bitumen. The cost of construction was unbelievably low.

• •

¶ Why doesn't someone build an experimental brick road of 2½ in. brick on a stabilized soil subgrade with hot bitumen surface treatment and thin mastic cushion under it?

• •

¶ We like Idaho's recently received last biennial report of the Department of Public Works, 1935-36, not because of the inclusion of accounting data particularly, but because of inclusion and discussion of engineering policies governing the construction, maintenance and operation of Idaho's highway system. A. Puddle Jumper wonders if the highway department can manufacture new equipment economically as claimed on page 141 of the report. If all properly chargeable costs were added, including actual overhead time spent on design, discussion, and manufacture, and plant depreciation or machine rental, couldn't the highway department buy standard equipment cheaper than trying to make it? No equipment inventory or listing is included. Information on sub-divided maintenance costs would be enlightening.

¶ At hand is the recently issued last biennial report of the Division of Highways of the Department of Public Works, State of California. A voluminous report it is, too; just the kind that gives complete information on state highway department activities and the reasons and policies governing those activities. By selective reading and correlation with accepted engineering practice this report might well serve as a text book on highway construction and maintenance. A section that would be interesting and might be advantageously included is a discussion of highway economics on a state wide basis.

This is a report of which the authors may be proud.

¶ The picture herewith shows one of Michigan's progressive ideas. This state Highway Tourist Rest Room cottage is on U. S. No. 12, a few miles north of the Michigan-Indiana state line. The pavement is four lanes wide here.

• •

¶ If you want an answer to difficulties you encounter in applying the Social Security Law, send me your question. A. P. J. will see that it is answered by a recognized certified public accountant.

• •

¶ Shame for Kansas. Just before the Tractor Show and Southwest Road Show opened at Wichita the state was visited by a few-inch snowfall. The high wind caused drifting. Highway 40 from Kansas City to Salina (as far as I went) was in terrible shape. I passed two cars with broken axles. Apparently, Kansas doesn't believe in keeping main roads clear of snow or else they have no snow plows. Three days after the snowfall the ruts were terrible and I passed or saw nary a plow.

¶ Just west of Maysville, Missouri, a sub-oiling machine "shot" the road. That was last fall. The asphalt stabilizer is just showing. The road is smooth and firm. I'd like to see the machine tried in a heavy clay soil.

• •

¶ I hear rumors of a shakeup in Kansas in the State Highway Department. In a way, I feel that the present engineering staff was on the spot. A republican presidential candidate from a state that went democratic certainly put the engineering staff in a difficult position. Such is politics.

• •

¶ Did you know that annual road, street and highway expenditures are about 70 per cent of all construction expenditures now? It's true.

• •

¶ Those speedometer check and test sections in Missouri are a good idea. I noticed them in some other states, too.

• •

¶ Stop and go lights are all right in certain places. Allen, Mich., was "sold" one certainly. It is located at an intersection where one street dead ends into a railroad embankment 150 ft. from the intersection.

• •

¶ Now comes West Virginia with a de luxe edition highway map dated February, 1937. Historic spots and personages are pictured. Useful information and routes through cities are also included. Pictures show incidents regarding two of George Washington's brothers. This is the first time I ever knew George had a brother. How about you?

• •

¶ Don't forget to write me regarding problems you encounter in applying the Social Security Law.

• •

¶ I recently completed a small survey amongst our readers to find out what kind of articles they would like to see published. A large percentage of the replies checked the "New Equipment" item. The general reply, however, indicates that readers are particularly interested in just the type of articles we publish. Quite a few checked the item, "Diesel Engines." You can count on seeing some authoritative information on this.

¶ H. J. Res. 227, a bill introduced in the House in Congress provides for "Creating Transcontinental Superhighways Commission."

• •

¶ H.-R. 4198, a bill introduced in the House in Congress provides for "the location, survey, and building of a system of those transcontinental and six north-south highways." These are to constitute a national system.

• •

¶ Chairman Cartwright, of the House Roads Committee, has advised that the Federal Government is now considering reduction of Federal-aid apportionment to New Jersey and other states because of diversions heretofore made, and in violation of Section 12, of the Hayden-Cartwright Act.

• •

¶ Highway contractors operating in Mississippi perfected, on February 22, the Mississippi Highway Contractors Association with the following set-up:

President—M. G. Cobb, Cobb Bros. Construction Co., Meridian, Miss.
Vice-President—S. B. Ziegler, Ziegler Construction Co., Nashville, Tenn.
Sec'y-Treas.—E. A. Hoffpauir, Dunn Construction Co., Jackson, Miss.

Robert N. Kinnaird, of Jackson, who has been employed as an engineer for the state highway commission, was elected executive secretary.

Following directors were elected:

Wade Moore, Forcum-James Construction Company, Dyersburg, Tenn.; John Harbert, Harbert-Cargile, Birmingham, Ala.; Frank Barber, Barber Bros. Construction Company, Baton Rouge, La.; C. F. Shuptrine, Shuptrine Construction Company, Jackson, Miss., and Alex J. White, V.-P., West Construction Company, Chattanooga, Tenn.

Mr. Hoffpauir explained that the purposes of the association will be, among other things, to promote ethical standards among highway contractors and to correct alleged "unfair practices."

Among the "unfair practices" which the secretary enumerated is the seduction of skilled labor from one contractor by other contractors who need such workers on their own projects. Mr. Hoffpauir declared that this is one of the greatest evils at present, due to a pronounced shortage of skilled labor available for service on current construction projects.

• •

¶ From the Legislative Bulletin of the American Road Builders' Association we learn that:

The Roads Committee met for the first time on February 17th and heard discussions on Bill H. J. Res. 182; which is for the purpose of appropriating in the flood-devastated areas, $100,000,000 as an emergency fund for the repair of roads and streets. Action on the bill was deferred until a report is received by the committee from the Bureau of Public Roads as to conditions and needs for repair and reconstruction.

—

In the House, Bill HR-4791 was introduced by Representative Beiter. This Bill would continue federal emergency administration of Public Works until the close of business June 30, 1939, appropriating $300,000,000 for the purpose. Referred to the Committee on Ways and Means.

This Bill will undoubtedly be of interest to many as there are a number of PWA projects which have been approved as to eligibility but for which there are at present no funds available.

• •

¶ A bill to tax bicycles was introduced into the New Hampshire Legislature, January 22, 1897. It was amended on February 4 to provide that "the income be applied to repairs of highways in addition to the amount otherwise required by law to be raised and appropriated"; was passed by the House of Representatives the same date and messaged to the Senate. Evidently, it was a momentous question for it was not until March 11 that the Honorable Senate solemnly voted "inexpedient to legislate."

• •

¶ Public Works magazine reports 34,000 Bureau of Census enumerators found only 2116 contractors who did more than $500.00 worth of highway and street business in 1935. That averages 16 enumerators to each contractor. Looks like a good job for J. Edgar Hoover's boys if busy contractors are that hard to catch.—*—From the Elbee Tatler.*

• •

¶ Champaign, Urbana, and the University of Illinois were good hosts at the Twenty-fourth Illinois Highway Conference, March 3 to 5.

• •

¶ Under the direction of Prof. C. C. Wiley, the program moved snappily from 8:30 A. M. to 4:30 P. M. each day.

• •

¶ And the old blue serge took on new brilliance. Boy, how we wished the regents had appreciated the importance of upholstery in that big lecture room!

• •

¶ Coach Bob Zuppke, speaking at the opening smoker, made some of us feel twenty years younger. Old Bob seems to think there is real value in giving your best to the job even though you've seen 40 summers—or 50. Funny idea, isn't it?

• •

¶ Don't tell Urbana's police chief everything that was said that evening by the city's genial Mayor. His Honor has the right spirit.

• •

¶ Let the engineers stop squawking at their lack of public recognition! His Honor says we are the most artistic, prolific, proficient and efficient cussers he knows.

• •

¶ And it is stated that, though a modest man, His Honor has talents of his own in this field. Strange, considering the large part of his life spent contracting.

• •

¶ Well, it was a good meet. No time to get any of the technical papers in this issue of ROADS AND STREETS, but we hope to run some of them later.

• •

¶ Many thanks, Faculty, Twin Cities, and all who helped. We're counting on an invitation next year.

¶ Ancient going to Modern—On the Road to the Airport at Iuka, Mississippi.

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# EDITORIAL

## How Many?

ONE of the magazines with a general circulation in the engineering construction field published an editorial last month in which a figure was quoted from the Census Reports of 1935. It occurred to us that some explanation should be made regarding the figure quoted lest they become misleading.

The census report does stipulate that the bureau contacted 2116 contractors that *they* classified as highway contractors. The same report also broke down the contractors into General and Special Trade, with 11,491 in the former and 63,556 in the latter. They broke the general contractors down into Building, Highway, and Heavy. A study of the rules and instructions to enumerators as well as an analysis of the report form indicates that the bureau placed many road, street, bridge and highway contractors in other classifications. For example, footnote 1 of Section 4 of Form 6 includes the following in heavy construction: Grade separations involving a railroad, pile, driving, foundations, piers, abutments, retaining walls, tunnels, elevated highways, etc. There being very little railroad construction work and most of the sewer and water works jobs being WPA projects it stands to reason that the big percentage of construction listed as heavy is some phase of highway work. Further, if we may accept the statements of Mr. Klinger, president of the Associated General Contractors of America, we learn that from 1930 to 1934, inclusive, public construction averaged 80% and private construction 20% of all construction. From the same source we learn that the total average construction volume for those years was about $3,000,000,000. The year 1935 was not much different from this except for perhaps an increase in volume.

Following is a tabulation of the value of all road, street, bridge and highway projects for 1935, made from published reports and data:

| | |
|---|---|
| *Federal* | $ 882,316,078 |
| *State*— | |
| PWA sponsors funds (55% ratio required) | 56,486,300 |
| State Highway Departments (to match federal funds plus that spent as state funds) | 207,911,000 |
| Local roads, streets and highways not on state systems | 58,166,000 |
| State forest roads | 55,000,000 |
| *County*—County and township roads | 211,520,000 |
| *City*—(100,000 population and over) | 60,000,000 |
| *Cities and Towns*—(Under 100,000 population) city and town streets and alleys, estimated | 60,000,000 |
| Total construction | $1,541,399,378 |

To these figures should be added the maintenance expenditures, since that work is a form of construction and uses more equipment than construction work.

| | |
|---|---|
| *Maintenance*— | |
| State highways | 184,458,000 |
| County and township highways | 317,280,000 |
| City streets (100,000 population and over) | 140,000,000 |
| Cities and towns (under 100,000 population estimated) | 140,000,000 |
| Total road, street and highway field | $2,323,137,378 |

A similar condition existed in 1936, with perhaps an increase because of the more completely organized Works Progress Administration expenditures. 1936 was a bigger year in every way. Data for breakdown of items are not available for 1936.

From this it is easily seen that of all public expenditures, even all construction, highway expenditures constitutes the big percentage by a wide margin. Certain it is that more than 2116 contractors were required to do these jobs.

In his paper presented before the American Road Builders' Association convention in January, 1936, Mr. T. H. MacDonald shows that 12,165 separate highway projects were accomplished on Federal Aid projects only. If we allow two projects per contractor (a very liberal assumption) we find over 6000 highway contractors at work on Federal Aid construction alone.

Our own recent surveys show that over 10,000 different street and highway contractors have had work within the last year and a half.

In view of all of this evidence there seems to be no doubt that at least 10,000 contractors are engaged in road, street, bridge, airport and highway construction. An anomaly hard to understand about the census figures is this comparison:

During 1935 Mr. MacDonald's report indicates estimated cost of contract Federal Aid highway work is $596,463,000. The census report shows $280,332,000 total for all street and highway contractors. We wonder who did the balance and how did the census bureau classify *them?*

▼

## In Trouble?

PRACTICAL application of the Federal Social Security Law to contract work involves many obscure interpretations of the act and what may seem to be an endless amount of book- and record-keeping. Such questions as part time employment in one state and removal to another, end of month coming in middle of week, customary payroll week ending on a Friday, transferring skilled mechanics from one job to another, unemployment between jobs, and many others confuse the average contractor's bookkeeper. He is now in a bit of a quandary as to how to set up records to comply with Federal and State old age and unemployment insurance acts. Just when a man is subject to the tax and when not is apparently a point not clearly understood, also what is meant by *casual labor.*

To help in clearing up some of these questions, ROADS AND STREETS will publish a series of articles by a recognized certified public accountant. The first of this series will appear in the next issue. It is expected that by the time the series is complete a contractor may wish to adopt one of the bookkeeping and record-keeping systems that will be presented.

The author of the articles has requested that contractors submit questions to us so he may answer them in the articles. Shoot in your questions *now.*

# NEW EQUIPMENT AND MATERIALS

## New Concrete Bucket

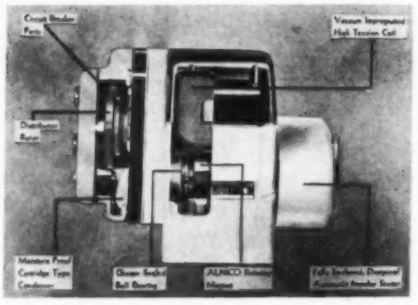
A new type of all-welded cylindrical concrete bucket, particularly designed for convenience in operation in close forms and for handling low slump concrete, has been perfected by the Dravo Corporation, Pittsburgh, Pa. The bucket, made in 2-yd., 3-yd., and 4-yd. capacities, is a bottom dump controllable type. It has no projecting levers and is operated entirely by a hand wheel set into the outer shell of the bucket. Two wheels are provided on the 4-yd. buckets. Besides facilitating the opening of the bucket in cramped quarters, the design provides an added safety feature in that there are no projecting parts to catch on forms, reinforcing steel, or clothing of men operating the bucket. In operation, it was found that the method of mounting the control gate was such as to make the bucket self-closing, and it can be closed readily when only part of the concrete has been poured. Following the use of a trial bucket at the Joe Wheeler Dam being built by the Tennessee Valley Authority, 17 additional buckets were purchased. Buckets later were sold to other users.

*New Concrete Bucket*

▼

## New Magneto in Low-Priced Field

The Edison-Splitdorf Corporation, West Orange, N. J., has announced a new machine to be known as the Edison RM Magneto. The RM is of the rotary magnet type, for practically all types of spark ignition engines. The machine is fixed spark and built for base or flange mounting. Features of design and construction are of typical Edison high quality.



*Edison RM Magneto*

All bearings, both main and distributor, are grease-sealed, ball bearings of first quality. The housing is a rigid die casting in one piece, sealing the entire magneto against dust and moisture. The distributor is of the "wipe" spark type, used almost universally in the largest and most expensive magnetos. However, it is also available with "jump" spark where that is specified. The circuit breaker is gear-driven, operating at only one-half to one-third the speed of magnetos of conventional design. This feature greatly reduces wear on the circuit breaker parts. The breaker spring is of beryllium copper—an expensive material that is fatigue-proof and corrosion-proof.

The impulse starter is the same unit used in larger, more expensive Edison Magnetos. It is completely enclosed and fully automatic in operation. The coil of the RM is fully vacuum impregnated to insure permanent high efficiency.

For the first time in standard commercial magnetos, a new magnetic material called Alnico has been used in the rotors of the RM. This new alloy has been acclaimed by metallurgists for its superior magnetic properties.

▼

## New Finish Spreader

The Foote Co., Inc., of Nunda, N. Y., prominent manufacturers of road building machinery, have announced a new finish spreader.

This spreader known as the Adnun finish spreader is designed to handle and spread all types of road stone, slag, gravel and cinders. Its use is stated to eliminate the need of a grader and to avoid waste of materials and over-run.

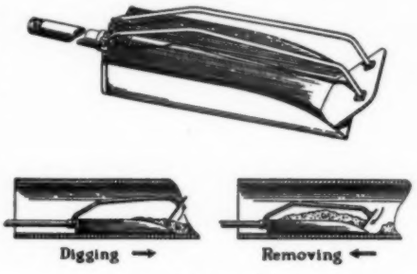
Among the outstanding advantages claimed for it are: Simplicity of design assures low first cost and as there is no engine and few moving parts, maintenance costs are low. It is fast on the job and accuracy is assured by long guide rails which span the small irregularities that may be present in the sub-grade. The Adnun finish spreader will shape any crown or bank, and the crown or bank contour can be changed while in motion. The spreading width is variable and easily adjusted up to 11 feet and material can be laid right to the curb.

▼

## Culvert Cleaner

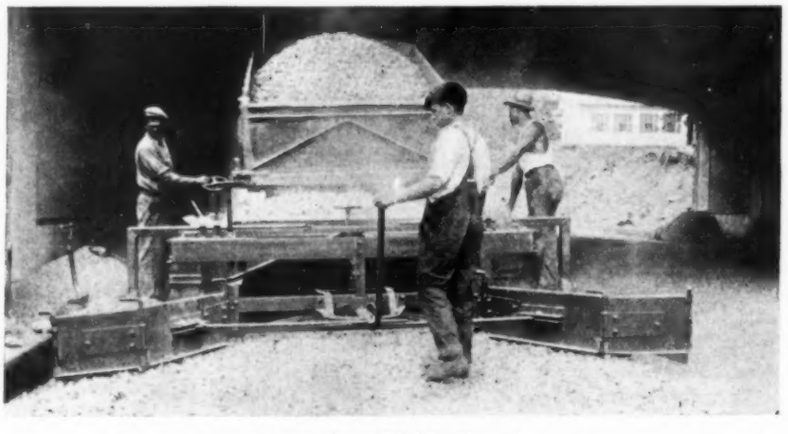
A tool, designed to solve the difficult problem of removing dirt from filled or partly clogged culvert and drain pipes that extend many feet underground, has been brought out by the Monarch Road Machinery Co., Grand Rapids, Mich.

A combination shovel and hoe, it both digs and holds the material in the scoop. When digging, the hoe section automatically lifts up permitting material to fill the scoop. Withdrawing, the hoe section drops down which prevents dirt from dribbling back into the pipe.

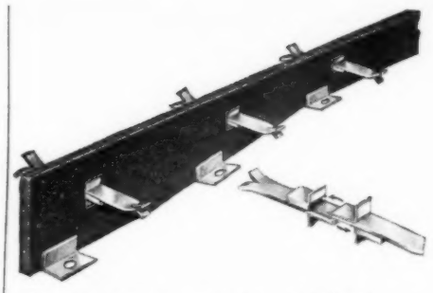



*Morco Culvert Cleaner*

Handle is made up in sections ¾ in. water pipe and can be extended to any desired length. Scoop is designed for us in 10 in. and larger size pipes.



*New Adnun Finish Spreader*



*Double-Dowel and Its Application.*

## New Device for Transmitting Load at Joints

Highway Steel Products Company, Chicago Heights, Ill., have developed a load transmitting device known as the "Double-Dowel" for use at expansion joints. It is composed of two identical members which fit together into one complete unit. Each member is a combination of a 5/16 in. x 1½ in. plate, fabricated with a fish-tail end to secure a strong anchoring bond in the concrete.

To the smooth end of the plate is attached a specially designed sheet steel member that loops over the end, forms a box to provide a free space into which the other plate moves with the expansion and contraction of the slab and provides the vertical flanges that hold the unit perpendicular to the joint filler.

The sheet metal member is made of 18 gauge black sheet steel and is so constructed that it is held securely in position and will allow no movement.

The distance from the end of the plate to the vertical flange is 3 inches which allows 2 inches of the plate to extend in the adjacent slab when a one-inch joint filler is used. The vertical flanges extend 2 inches above and below the bar on each side of the joint.

The method of fabricating Double-Dowels prevents any free space between the sheet metal case and the flat bar, thus eliminating the danger of initial deflection when a load is applied. Although the members fit very snugly together, the combined unit, because of its construction, operates freely with the movement of the pavement.

A specimen tested by Phil C. Huntly, Professor Mechanical Engineering, Armour Institute of Technology, Chicago, Illinois, consisted of a 7-in. uniform concrete slab 48 in. long and 20 in. wide, the length being divided into three sections, 15, 18 and 15 in. respectively. The slab sections were separated by a one-inch premolded expansion joint with a Double-Dowel plate spaced midway between the ends of the joint member. The joints were 20 in. long.

A 1:2:3½ mix using high, early strength cement was used and the sample tested was 20 days old. The center slab between the joints was unsupported and a vertical load was applied on the top of this slab. The two end slabs were supported underneath within 1⅜ in. of the joint and were held down by clamps.

The results of this test follow:

| Load | West Dial | East Dial |
|---|---|---|
| 2,000 lbs. | .002 | .006 |
| 4,000 lbs. | .005 | .009 |
| 6,000 lbs. | .0095 | .013 |
| None | .002 | .004 |
| | Dials Reset | |
| 2,000 lbs. | .003 | .0045 |
| 4,000 lbs. | .0065 | .007 |
| 6,000 lbs. | .0085 | .011 |
| 8,000 lbs. | .016 | .015 |
| 10,000 lbs. | .024 | .023 |
| 12,000 lbs. | .037 | .033 |
| 14,000 lbs. | .052 | .042 |

No further pressure was applied.

▼

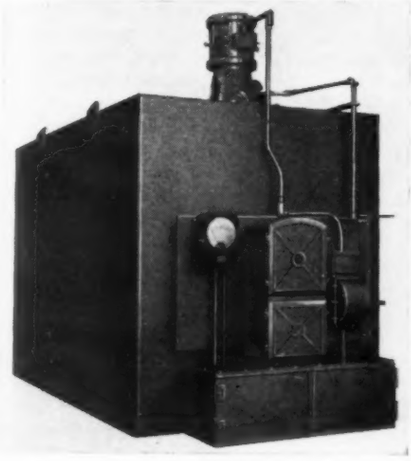
## Electric Bitumen Heater

Under license from the British inventors and patentees the Easton Car & Construction Co., Easton, Pa., will manufacture in this country the Clarmac electric bitumen heater. Over 100 of these heaters are now in use in England.

The heater is a rectangular steel tank equipped with electric heating elements. The heating elements are uniformly disposed in the bottom of the tank. The

number of heating elements required varies according to the size of the tank. The heating elements are under control of switches, thus permitting as many as desired to be operated under the automatic control. A main contactor or magnetic switch which is actuated by a sensitive thermostatic control automatically maintains the desired temperature of the bitumen.

The pumping apparatus consists of a gear-type pump submerged in the bitumen,



*Easton-Clarmac Electric Bitumen Heater*

just above the heating elements. The pump is driven by a vertical reversible motor located on top of the tank. The supply pipe to the mixer is of the return type, so that while the pump operates continuously, the bitumen not drawn off is returned immediately to the heater. At the end of the day's run the pump is reversed and this pipe line is emptied. The pump is then turned off for the night. This system is stated to dispense entirely with all need for steam heating the supply pipe line.

The heaters can be furnished in any desired capacity. They are usually supplied large enough to contain either the average or maximum day's supply of bitumen. The 3000 gal. heater is approximately 7 ft. x 7 ft. x 10 ft.

▼

## New Highway Flare Torch

R. E. Dietz Co., New York, have recently added to their well-known line of highway flare torches a new one, known as No. 87. This is a strong, dependable torch of self-righting, spherical type, with weighted bottom, and has a burning capacity of 24 hours. It has a new and very efficient windproof burner with fixed rain shield, fully licensed. Fuel used is kerosene or light fuel oil, operating with 7/8 in. round wick. Finish is red enamel. This new torch is competitively priced and meets the low cost requirements of all types of users.


*New Dietz Flare Torch*

## New Application for "Freflo" Centrifugal Pumps

Worthington Pump & Machinery Corporation, Harrison, N. J., has announced the new application of their "Freflo" centrifugal pumps to underpass drainage. A simple catch basin or sump and an inexpensive housing are the only additional provisions required. Extra tanks, piping or valves are unnecessary.

These centrifugals are made in capacities of 85 to 7,500 gals. per minute and are extremely simple to operate. The

services of an attendant can frequently be dispensed with by equipping the pumps for automatic starting and stopping.

Among the advantages claimed for the "Freflo" pumps is the flared suction inlet that reduces entrance losses and increases overall efficiency. The free passages through the impeller and casing, and the ball thrust bearing, of ample size to carry the thrust load, all serve to make for a rugged, dependable unit. They are built ready to install, with the foundation plate and driving head frame of heavy fabricated steel supporting the entire weight of the pump and driver.

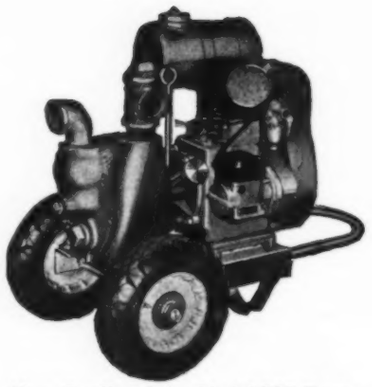
A descriptive bulletin, W-317-B5, will be sent upon request to the manufacturer.

▼

### A New Pump with a New Engine

A new Model 7M 7,000 gal. per hour pump equipped with new Wisconsin single cylinder air cooled 2½ in. bore x 2¾ in. stroke Model AB gasoline engine developing 2½ to 3 H.P. has been announced by the Sterling Machinery Corporation, 411-13 Southwest Blvd., Kansas City, Mo.

This new Sterling pump equipped with light weight Wisconsin engine with independent outside high tension magneto is claimed to be especially adapted for contractors' use and is an all around utility pump.



*New Sterling 2 in. Model 7M Pump*

## WITH THE MANUFACTURERS

### Loxterman Elected Vice President Blaw-Knox

The board of directors of the Blaw-Knox Co. has elected H. B. Loxterman a vice-president and Albert L. Cuff, secretary. In addition, the following officers have been elected to subsidiary companies: W. H. Eisenbeis has been made vice-president of the Union Steel Casting Co. and John Baker has been made sales manager of the Union Steel Casting Co. P. M. Fleming has been made vice-president and a director of the Pittsburgh Rolls Corporation.

### O. K. Clutch Appoints New Distributors

O. K. Clutch and Machinery Co., Columbia, Pa., has appointed distributors to handle its line exclusively, in the Pittsburgh district, the G. N. Crawford Co., 405 Penn Ave., Pittsburgh, Pa. and in the South Carolina district, Fred Marshall, Seaboard Park, Columbia, S. C.

▼

### Snodgrass Becomes Manager Gar Wood Coach Division

Logan T. Wood, vice-president and general manager of Gar Wood Industries, Inc., Detroit, Mich. announced the immediate appointment of H. Sydney Snodgrass as manager of the motor coach division to fill the vacancy created by the resignation of Stanley E. Knauss. Mr. Knauss has been manager of that division ever since the company began production of Gar Wood streamlined motor coaches. Mr. Snodgrass, long associated with Mr. Knauss as the division's chief engineer and assistant manager, enters his new position with a complete, thorough knowledge and understanding of the manufacturing and administrative policies and plans of the division. The present plans of Mr. Knauss include an extended stay in Florida. Later it is his intention to establish his own business, the character of which was not revealed.

### Gibson Elected President Wellman Engineering Co.

Alfred E. Gibson has been elected president of The Wellman Engineering Co., Cleveland, Ohio, succeeding Mr. George W. Burrell who becomes chairman of the board.

Mr. Gibson first worked for the company during summer vacations when in college, and upon his graduation in 1909 from Ohio State University, he entered the employ of the company in its operating department, later becoming superintendent of its Cleveland plant, then general superintendent in charge of both its Cleveland and Akron, O. plants.

In 1926 he left Wellman and became associated with the Fulton Foundry & Machine Co., Cleveland, Ohio, as vice-president, later being elected president.

In 1928, upon the election of George W. Burrell as president of The Wellman Engineering Co., Mr. Gibson returned to the Wellman Company as its works manager. In 1930 he was elected vice-president and in 1931 vice-president and assistant general manager in charge of engineering and shop production, and in 1935 was appointed executive vice-president and now becomes its president. The Wellman Company, under Gibson's direction, has widely extended the use of the welding processes and made extensive applications of the new low-alloy, high strength steels, to its engineered products.

Mr. Gibson is president of the American Welding Society; a member of the American Society of Mechanical Engineers; the Iron & Steel Engineers; the Society for Metals; the International Acetylene Association, and has made a reputation for himself as an authority on the development and application of low-alloy steels in welded constructions, having appeared on the programs of many societies and technical colleges the last few years.

▼

### Warriner Appointed Works Manager Wellman Engineering Co.

Announcement is made of the appointment of J. Harry Warriner as works manager of The Wellman Engineering Co., Cleveland, O. Mr. Warriner started working for the Wellman Co. in 1905 as toolroom boy, afterwards serving an apprenticeship as machinist, and later becoming its shop estimator. In 1919 he was placed in charge of production and estimating at the company's Akron, O., plant. In 1925 he returned to Cleveland, having been promoted to the sales department and assigned to special sales work, and served in this position to the time of his recent appointment as works manager. "Harry," as Mr. Warriner is familiarly, and well known to the industry, has a record of 32 years' of continuous service with The Wellman Engineering Co.

### Potland Cement Association Appoints New District Engineers

The appointment of A. M. Davis as district engineer of its Michigan office with headquarters at Lansing, the naming of A. W. Rohlwing as district engineer in charge of its work in Indiana and Kentucky with headquarters at Indianapolis, and the appointment of A. F. Unckrich as district engineer in charge of its Columbus office with supervision over the work in Ohio and West Virignia has just been announced by W. M. Kinney, General Manager of the Portland Cement Association.

Davis has for the past two years been chief field engineer for the association in Michigan and has been with the Association since 1928. He is a graduate of Purdue University, holding a degree of civil engineer and is a member of the Michigan Engineering Society.

Mr. Rohlwing has been with the association since 1927 and has held various responsible positions in the field since that time, Since 1936 he has been attached to the Indianapolis office as structural field engineer. He replaces H. J. McDargh, recently appointed regional manager, Southeastern Offices with headquarters at Atlanta. He is an alumnus of Tri State College and an associate member of the American Society of Civil Engineers.

Unckrich has been a member of the association staff for the past 13 years and since 1934, chief field engineer in Ohio. He is

an alumnus of Ohio Northern University and holds a degree of civil engineer from that Institution. He is a member of the National Association of Professional Engineers, Society of Professional Engineers and the Engineers Club of Columbus.

▼

### "Caterpillar" Appoints Galvin Sales Chief

H. P. Mee, Vice-President of Caterpillar Tractor Co., announces the appointment of E. R. ("Ed") Galvin as general sales manager of the company, effective March 1, 1937.

Mr. Galvin, who is one of the most widely-known men in the tractor industry and in industrial sales circles generally, left his position as general sales manager of Cleveland Tractor Co. in 1928 to become a district representative for "Caterpillar," contacting in the field a small group of the company's dealers. Shortly thereafter he became sales manager in charge of the eastern sales division, with headquarters at Peoria. In January, 1936, he was appointed assistant general sales manager, from which position the new appointment is a further step of advancement.

Prior to his connection with the tractor industry, "Ed" Galvin was for many years a member of the Du Pont organization, reaching with that company the position of manager of the sporting powder division. Making his work also his hobby, he long held a place close to the top among trapshooters of the United States and an enviable collection of trophies is evidence of his prowess in that sport.

Mr. Mee, who as vice-president, not only has had immediate supervision of the sales department but also direction of advertising and service activities, relinquishes the direct supervision of the sales department for broader duties of directing all sales, service and advertising activities, and to assist more fully in general company administration matters.

▼

### Universal Announces New Officers

The Universal Crusher Co. of Cedar Rapids, Iowa, at their annual meeting of recent date, elected a new group of officers in line with their policy of expanding their activities in the field of crusher equipment, portable washing and screening plants, and accessory handling equipments.

A. W. Daniels has been elected to the office of president and H. F. Rikhoff, secretary and treasurer.

L. S. Hackney has been appointed sales manager, and L. W. Dunlap, assistant general manager.

The two first-mentioned officers are new members in the organization, having both been with the American Manganese Steel Co. in executive capacities during the past many years.

The announcement of the new official arrangement also contains several additions to Univerasl's extensive list of distributors.

Universal carries a complete line of repair parts at twelve strategically located warehouses so that Universal customers can be served in their own territory with genuine Universal repair parts on a 24-hour day schedule, eliminating all necessity for substitution of parts and lengthy shutdowns.

▼

### Le Tourneau Organizes Promotional Engineering Department

Organization by R. G. Le Tourneau, Inc., Peoria, Ill., of a promotional engineering department with Kenneth F. Park as manager is announced by President R. G. Le Tourneau.

This department, through visits of its staff to earthmoving projects throughout the United States, will accumulate and maintain for the benefit of contractors and others a constantly current fund of data on the best construction practices. The services of its engineers are available on request for estimating earthmoving on proposed projects.

Another duty of the promotional engineering department will be the developing of new applications for Le Tourneau equipment.

Promoted from assistant eastern sales manager, Mr. Park, an associate member of the American Society of Civil Engineers, comes well equipped to his new duties. He chiefly is responsible for the Le Tourneau time studies, job action photographs and project data that have been invaluable to contractors and distributors in the preparation of estimates during the past eight years.

Twenty years of actual field experience as engineer, superintendent and foreman on earthfill dam, highway, levee, canal and other construction has acquainted him thoroughly with the earthmoving problems of contractors.

▼

### John May Now General Sales Manager of American Steel & Wire Co.

Dennis A. Merriman relinquished his title and duties as general sales manager of the American Steel & Wire Co., a United States Steel Corporation subsidiary, on March 1, 1937, according to an announcement by C. F. Blackmer, president of the wire company. Mr. Merriman continues as vice-president of the company and will maintain his offices at 208 South La Salle St., Chicago, Ill., until he reaches the age of retirement in September of this year.

John May, formerly assistant general manager of sales in charge of electrical cables and wire rope sales at this company's Worcester, Mass., office succeeds Mr. Merriman as general manager of sales. Mr. May will make his headquarters at the company's offices in Cleveland, O.

▼

### New Appointments in Universal Atlas

New appointments in the Universal Atlas Cement Co., a United States Steel corporation subsidiary, effective March 1, are announced by Blaine S. Smith, President of the company, as follows:

O. N. Lindahl, comptroller and secretary; J. J. Heffernan, Assistant Secretary; Leonard Wesson, Operating Manager; S.

J. Robison, Chief Engineer; O. L. Moore, Director of Tests and Research; J. C. Witt, Manager Research and Development; T. A. Hicks, General Chemist; G. L. Lindsay, Engineer of Tests; R. B. Hynes, Purchasing Agent; E. D. Barry, Manager of Industrial Relations; Gordon C. Huth, Assistant Manager, Industrial Relations.

All the appointments are of men with long service with the Universal Atlas company, according to the announcement.

Mr. Lindahl, the new comptroller and secretary, formerly was auditor and assistant secretary and has been connected with the company for 30 years. Mr. Heffernan, assistant secretary, has been in the secretary's office for 7 years and with the company 12 years.

Mr. Wesson, operating manager, was assistant operating manager and has more than 27 years' experience in the cement company. Mr. Robison, chief engineer, was assistant chief engineer and has been with Universal Atlas for 29 years. Mr. Moore, director of tests and research, was engineer of tests and with the company since 1914. Dr. Witt, director of research and development, was chemical engineer and is widely known in that field. Mr. Hicks, general chemist, has been with the cement company more than 30 years. Mr. Lindsay, engineer of tests, was assistant engineer of tests, with 20 years' experience.

Mr. Hynes, new purchasing agent, formerly was secretary, and has been connected with the concern for over 20 years.

Heading up the new department of industrial relations, Mr. Barry, formerly assistant operating manager, is a veteran of 34 years' experience with the organization. His assistant, Mr. Huth, previously was manager, bureau of safety and casualty, and has been connected with the company for 22 years.

All these appointments, it is pointed out, are promotions and reflect the Universal Atlas policy of advancing members of the organization as opportunities arise.

▼

### "Caterpillar" Forms Central Sales Division

Caterpillar Tractor Co., Peoria, Ill., announces the appointment of Louis B. Neumiller as sales manager of its central sales division. Edw. W. Jackson has been promoted to the office of general service manager, the position held by Mr. Neumiller prior to his advancement.

The central sales division is a sales area created by the division of the United States into three sales areas instead of the former two. In includes roughly the territory lying between the Rocky Mountains and the Mississippi River.

H. M. Hale is sales manager of the eastern sales division, H. H. Chambers of the western sales division and F. G. Nunnelly of Canada. All of these men make their headquarters at Peoria, excepting Mr. Chambers, who headquarters at San Leandro, Calif.

The realignment of sales areas has been prompted by the increase in the number of products manufactured, and by the constantly increasing diversification of markets.

▼

### Associated Equipment Distributors Elect Officers

The annual meeting of the Associated Equipment Distributors was held in New Orleans, Jan. 10, 11 and 12. President J. S. Gilman presided, second Vice-President acting as secretary in the absence of A. C. Blaisdell, Secretary, due to illness.

A joint meeting was held with the manufacturers' representatives on January 11, where subjects of mutual interest were discussed. The meeting was well attended by representative distributors from all parts of the country and a noticeable spirit of optimism was present.

Officers for the ensuing year were elected as follows: President, G. F. Lowe, Chicago, Ill.; 1st Vice-President, A. F. Sersanous, Portland, Ore.; 2nd Vice-President, Victor L. Phillips, Kansas City, Mo.; Secretary-Treasurer, A. C. Blaisdell, Cincinnati, O. Directors: J. S. Gilman, Minneapolis, Minn.; E. K. Hurst, Sioux Falls, S. D.; E. S. Jenison, San Francisco, Calif.; H. W. Fletcher, New Orleans, La.; E. P. Phillips, Richmond, Va.

▼

### Rubber Associates, Inc., Organized

A company, Rubber Associates, Inc., has been organized recently to engage in the manufacture of chemical products and plastic materials for all phases of construction projects and for manufacturing industries. Research laboratories will be maintained for all technical problems of the consumer. Associated with the company, which has its sales office at 342 Madison Ave., New York, are S. P. Tauber formerly connected with the McCarty A. & E. Co., Inc.; M. R. Buffington, Consultant on Rubber Materials; H. R. Van Deventer, Patent Expert; and a well known engineering consultant on application methods and construction practice.

▼

## NEW LITERATURE

*Portable Elevator*—The O. K. Clutch & Machinery Co., Columbia, Pa., has just issued a circular illustrating and describing its portable elevator for hoisting brick, mortar, cement and other building materials.

*Jackbits*—Ingersoll-Rand has recently issued a new booklet (form 2304) covering the characteristics and uses of jackbits for drilling rock. It also gives dimensions and prices of jackbits and jackrods. A copy can be secured by writing Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

*Power Shovels*—A catalog has just been issued by Bay City Shovels, Inc., Bay City, Mich., giving illustrations and specifications of Bay City Model 20, ⅜ yd. or ½ yd. capacity, full-revolving shovels, draglines and cranes. Ask for Catalog 20-A.

*Road Maintainers*—The York Superworkman—the road machine with a stone rake—is illustrated and described in a catalog issued recently by the York Modern Corporation, Unadilla, N. Y. This machine has three working units—a scarifier, a cutting blade and a stone rake. The catalog describes these units and gives specifications. Illustrations of the work they do are included.

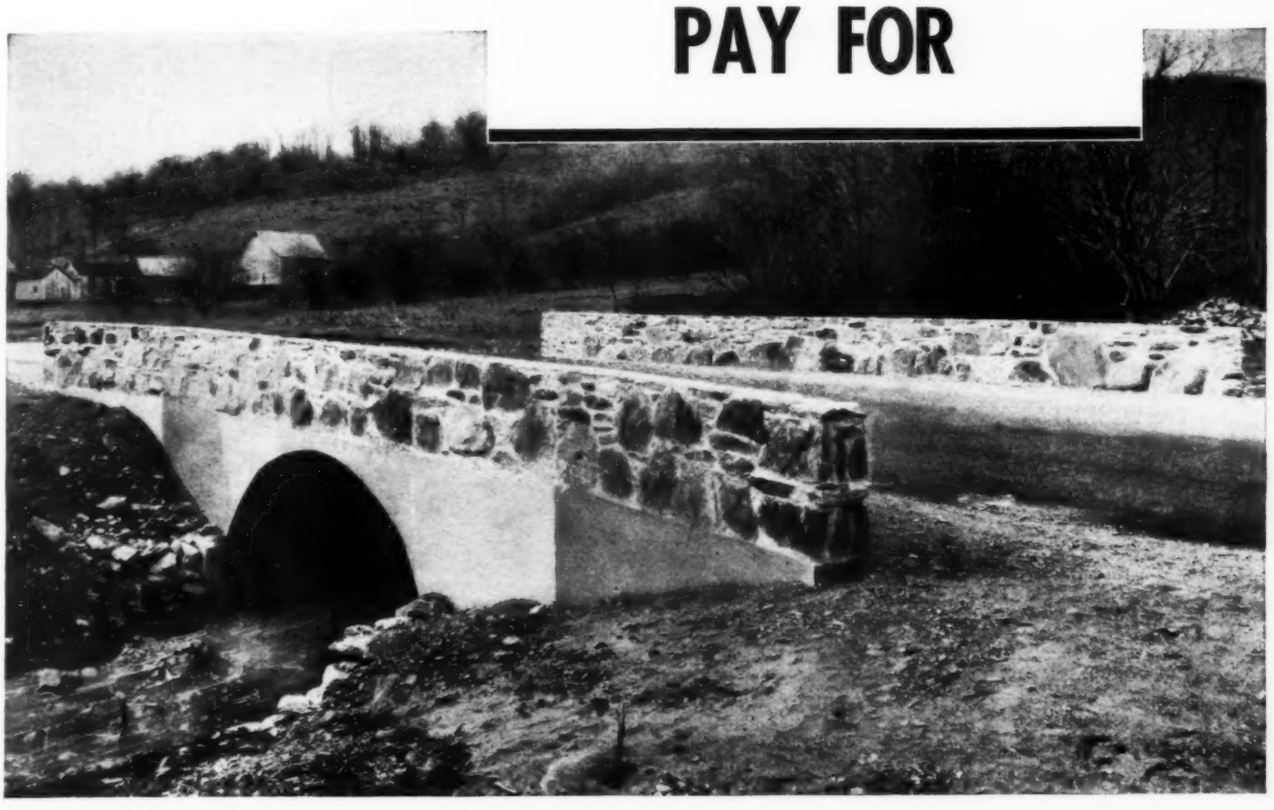
*Diesel Power Units*—A new Bulletin, 3600-A1, issued by the Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago, Ill., describes the construction and applications of its Model 36 Diesel power units. The Model 36 Diesel, offered in two cylinder sizes and in various combinations, with rating as low as 10 H.P., is the smallest in the complete line of Fairbanks-Morse Diesels.

*Lubrication Manual*—The "Alemite Industrial Lubrication Manual" has been thoroughly revised and is now offered free by the Alemite Division of Stewart-Warner Corporation, 1874 Diversey Parkway, Chicago, to maintenance men throughout industry. Besides listing Alemite industrial lubricants, this book is a comprehensive reference manual. It gives valuable data on where and when specific lubricants should be used, classified according to bearings, gears, etc., and also according to types of machinery. Included are several informative articles such as "Common Causes of Bearing Failures," "Lubrication of Anti-Friction Bearings," and "Grooving Bearings for High Pressure Lubrication." The book is printed in two colors and illustrated with photographs, detailed drawings and diagrams. Every industrial maintenance man should send his name on his firm letterhead to Stewart-Warner Corporation, 1826 Diversey Parkway, Chicago, Ill., and secure a free copy to keep handy on his desk.

*Road Machinery*—A very attractive pictorial catalog featuring its equipment in operation, and providing brief specifications and reference data, has been published by The Austin-Western Road Machinery Co., Aurora, Ill. It contains illustrations and descriptions of graders, road rollers, shovels and cranes, 5 yd. and 12 yd. scrapers, crushing plants and many other products of the company. Ask for catalog 1655.

*Hoists*—The Harnischfeger Corporation, 4400 W. National Ave., Milwaukee, Wis., has issued a new bulletin called "P&H Hoists." It is profusely illustrated with more than 25 industrial application photographs. It contains the treatment of both general and specific problems in the industrial handling field as well as many diagrams which explain simplified construction and operation, together with other vital points in modern hoist design. The bulletin lists the ratings and operating ranges for hoists from the 100 lb. capacity to 15-ton capacity sizes, as well as specifications and electrical accessories. Ask for Bulletin No. H-5.

# *Easier to* BUILD...LOOK AT... PAY FOR



DRAINAGE structures can be built quickly and at low cost with USS Sectional Plates. Skilled labor is not required, since the plates are light enough to handle with ease, and can be fitted and bolted together without the use of special, costly tools. Shoring is rarely necessary and forms are not required. The rapidity with which these plates can be installed saves time . . . reduces traffic delay.

Construction delays become a less important factor when USS Sectional Plates are used, and this method of construction is not seriously affected by adverse weather conditions. These Sectional Plates can be readily adapted to various design and landscape requirements.

Low construction costs make USS Sectional Plates easier to pay for; and assurance of long life continues this economy after the job is completed. An even coating of zinc over the durable base of copper steel gives added protection against corrosion. After years of service USS Sectional Plates may be taken up and moved to new locations, and continue to give years of service.

Our trained and experienced engineering staff is ready to assist you in solving your drainage construction problems. Further information on the use of USS Sectional Plates will be gladly sent upon request.

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Columbia Steel Company, San Francisco
*Pacific Coast Distributors*
United States Steel Products Company, New York, *Export Distributors*

*Copper-Steel Galvanized Sheets for smaller conventional types of roadway and drainage culverts are also made by:*
Carnegie-Illinois Steel Corporation, *Pittsburgh-Chicago*
Columbia Steel Company, *San Francisco*
Tennessee Coal, Iron & Railroad Company, *Birmingham*

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With which have been merged GOOD ROADS and ENGINEERING & CONTRACTING.

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THIS MAGAZINE IS DEVOTED TO

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